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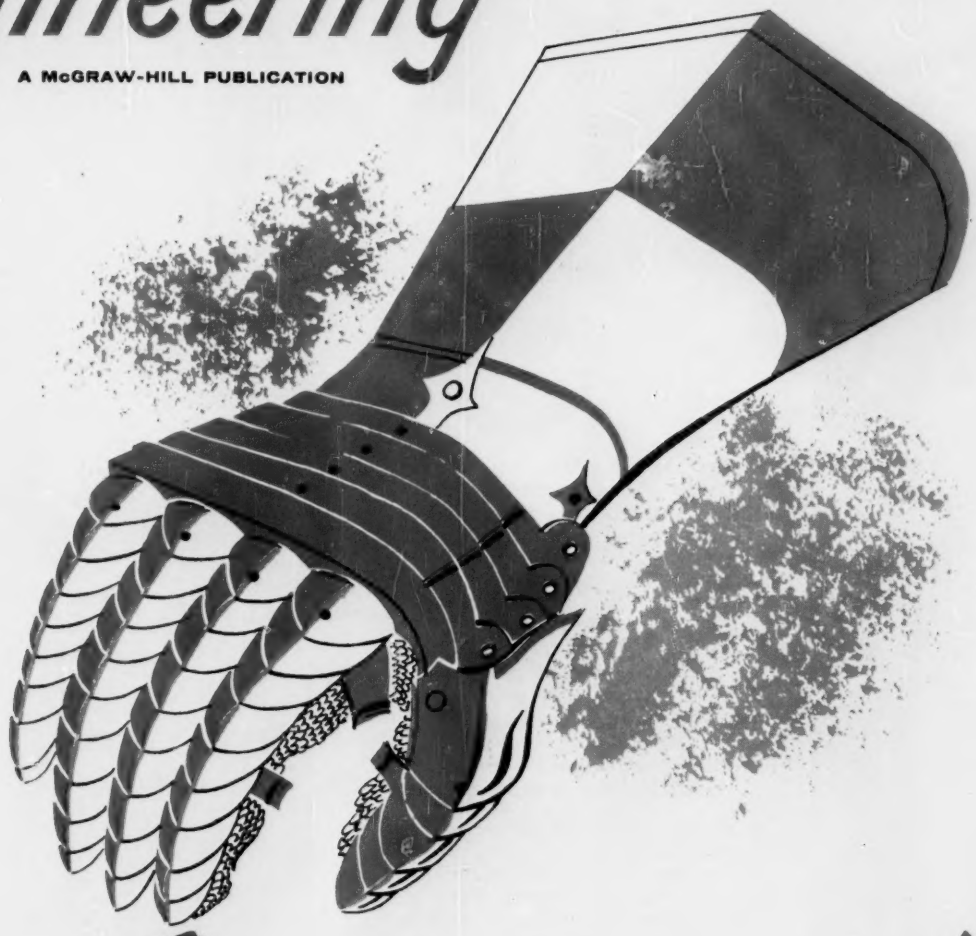
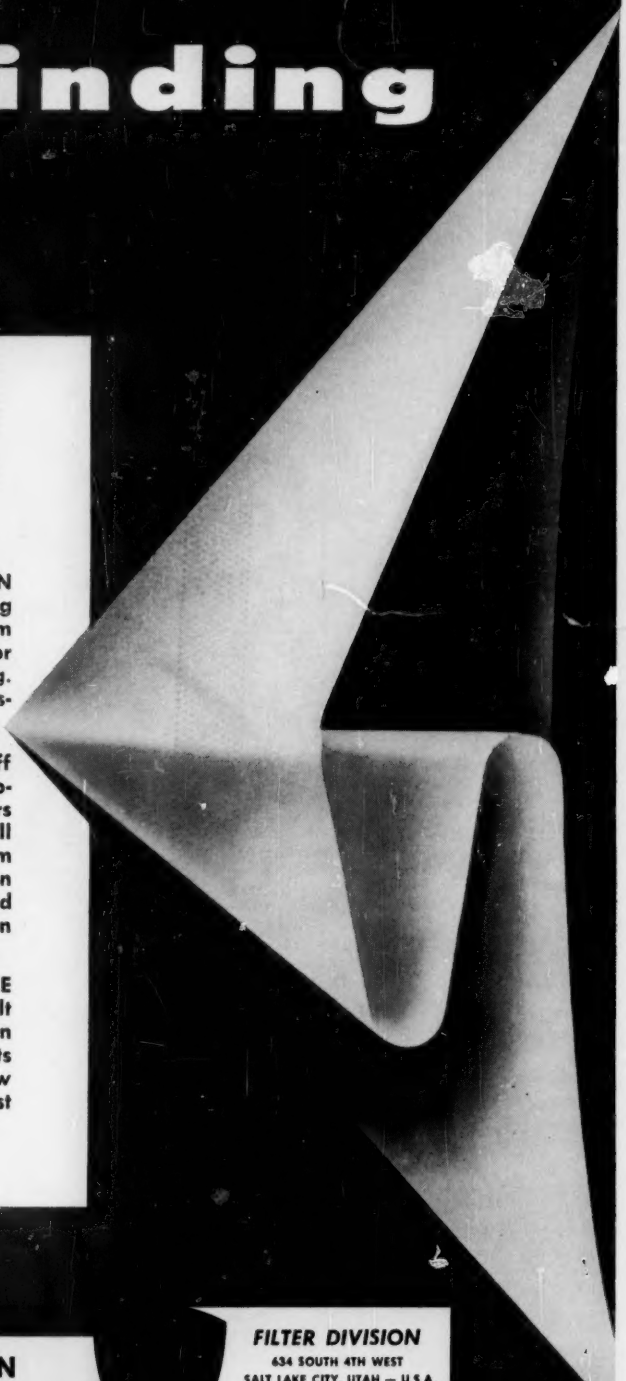


Challenge!

THE 60'S THROW DOWN THE GAUNTLET TO CHEMICAL ENGINEERS—A CE REPORT, P. 89

No Blinding



EIMCOBELT

Continuous Belt Drum

FILTER

FILTER MEDIUM ALWAYS CLEAN . . . EimcoBelt filter's new operating principle removes the medium from the drum every filter cycle for cake discharge and cloth washing. No "time out" for cleaning is necessary.

HIGH CAPACITY — With no fall-off in filtration rate caused by progressive blinding, EimcoBelt filters operate at rated capacity at all times. Average production is from one-half to two times higher than average capacities on standard drum filters. Required tonnage can be obtained with a smaller filter.

SAVES TIME AND MAINTENANCE — Cloth filter medium on EimcoBelt filter can be changed by one man in less than 30 minutes. Cloth lasts longer because there's no air blow to billow cloth medium against scraper.

THE EIMCO CORPORATION

FILTER DIVISION
634 SOUTH 4TH WEST
SALT LAKE CITY, UTAH — U.S.A.

RESEARCH AND DEVELOPMENT CENTER
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B.F.Goodrich

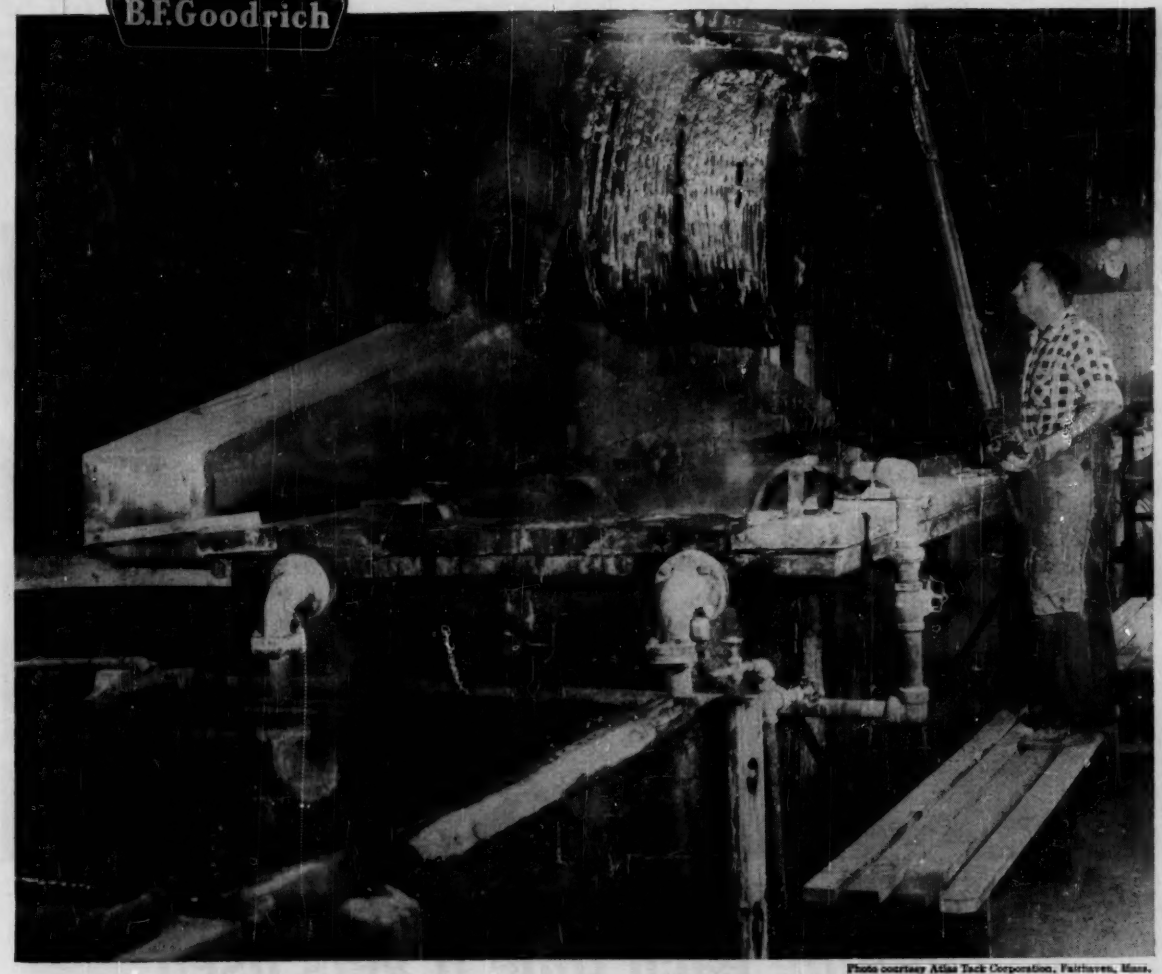


Photo courtesy Atlas Tack Corporation, Fairhaven, Mass.

1400-gallon cup of hot acid

B.F.Goodrich improvements in rubber brought extra savings

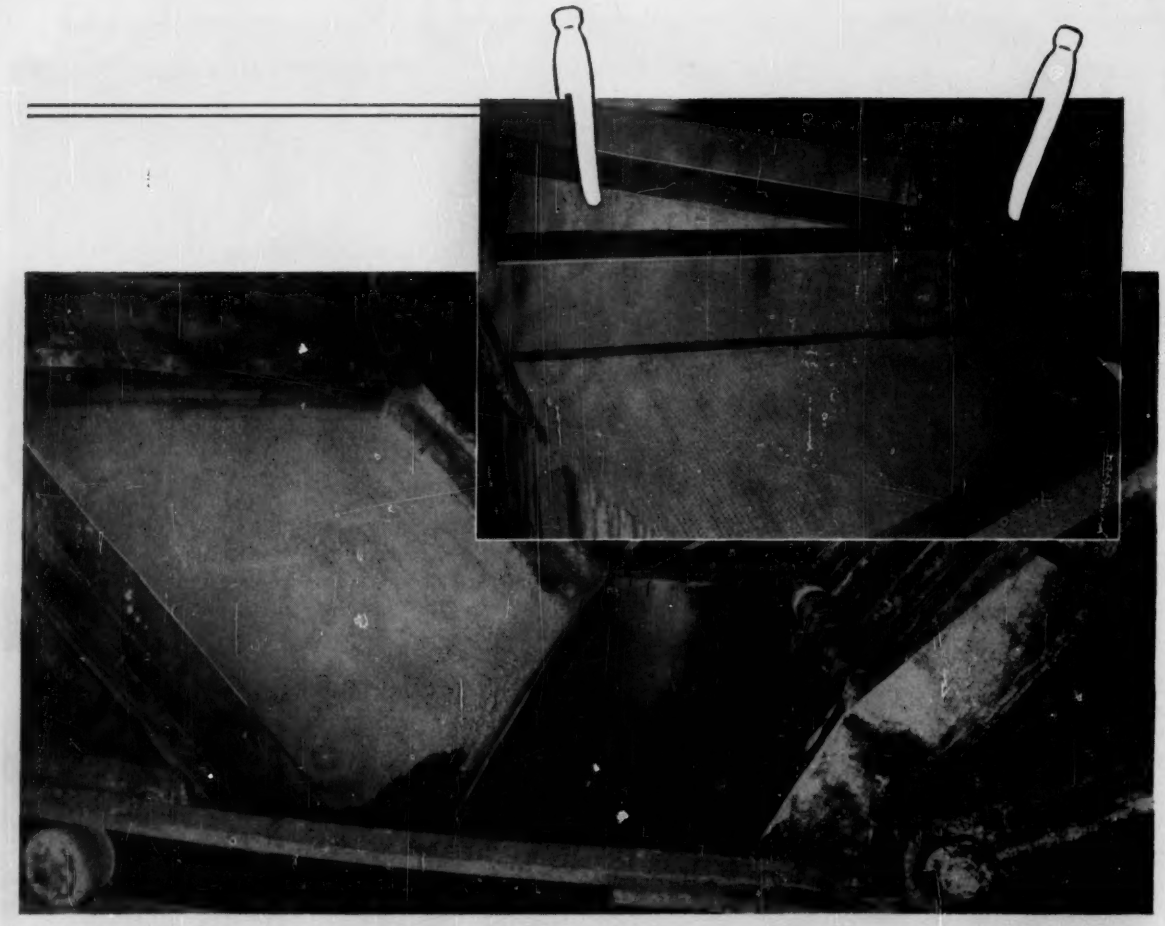
FOR many years, this job of cleaning rust and scale off coils of steel rods was done in tanks made of thick cypress planks. But tanks shrunk under the bite of hot acid, had to be calked and patched frequently, and were lasting only about a year.

A leakproof tank seemed impossible until B.F.Goodrich engineers came up with something entirely new in the way of a protective lining. They developed a combination lining of hard rubber sandwiched between layers of soft rubber that stands the most corrosive acids. This B.F.Goodrich "Triflex" lining, as it is called, is permanently attached to a steel tank, then protected from excessive heat, rips and tears by a sheathing of brick.

The waste and hazard of acid leaks stopped wherever this B.F.Goodrich lining was used. The tanks in the picture were lined by this method 10 years ago. Since then they've been in use 16 hours a day, have required virtually no repairs or maintenance. The company figures that in terms of useful service each tank has only cost them about 50¢ a day.

In the past 35 years, B.F.Goodrich has rubber lined thousands of tanks to handle acids and other corrosives. Some are still in use; others lasted 15 or 20 years. Not one ever failed to end costly shutdowns for repairs. When you specify tank linings, remember that the true cost is the price divided by the years of satisfactory service. On that basis, your cost will be lowest when you specify B.F.Goodrich. *B.F.Goodrich Industrial Products Co., Dept. M-772, Akron 18, Ohio.*

B.F.Goodrich *industrial rubber products*



Here's a filter that washes its own clothing each time it gets used

Once every operating cycle of the Bird-Prayon Tilting Pan Filter, after the cake is removed by gravity and by air blast, the cloth on each pan gets a high pressure shower and is dried by vacuum. It's fresh and clean as new before it takes on its next share of feed slurry.

What does this mean to you?

It means *continuous* production — no down time for cloth washing.

It means extra long cloth life — up to 8 months.

It means sharply reduced cost of cloth maintenance and replacement.

Virtual elimination of costly and recurrent filter media problems is but one of the advantages and savings offered by the Bird-Prayon Filter. Ask us to tell you what else it can do to help you produce a better washed, better dried product at lower cost per ton.

BIRD MACHINE COMPANY • South Walpole, Mass.

Regional Offices: Evanston, Illinois • Alamo, California • Atlanta 9, Georgia

BIRD-PRAYON *Horizontal Tilting Pan Filter*

January 11, 1960 **Chemical Engineering** Vol. 67 No. 1

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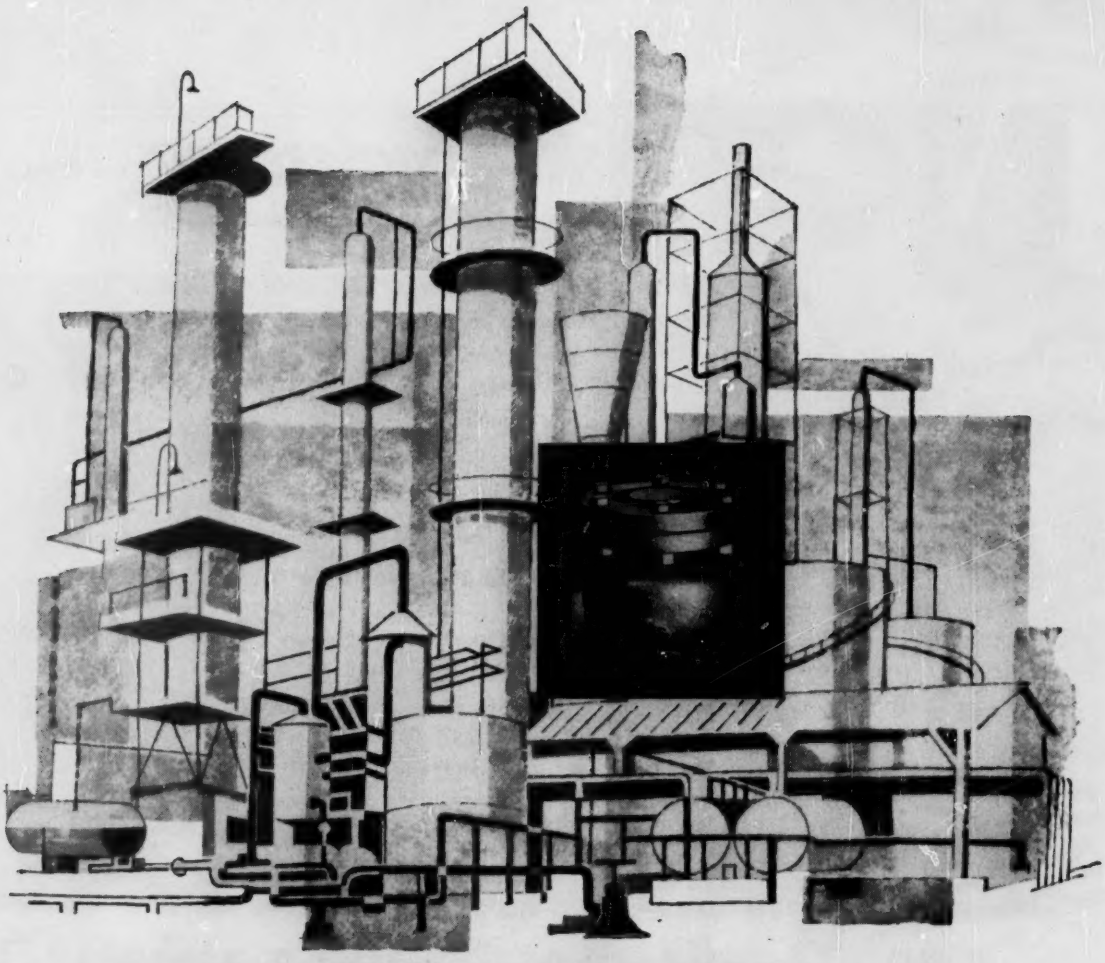

THE ECONOMICS OF STEAM TRAP SELECTION

Initial cost versus installed cost

Everybody wants to save money in the purchase of steam traps, or anything else.

But a wise buyer will recognize that the *real cost* relates to the entire useful life of his plant, and that selection of the most efficient trap for a given application is an important consideration.

Compare the efficiency of Nicholson traps with that of so-called "bargains" and you'll see why plant engineers responsible for successful operation usually insist on Nicholson.

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How lasting quality is
Heat Exchange

Fabrication of Phelps Dodge heat exchanger and condenser tubes starts with the casting of billets. In this process, high grade copper (over 99.90% pure) from Phelps Dodge's own mines is alloyed with the finest quality metals available. The alloys are melted in electric furnaces and cast in specially designed water-cooled molds that produce sound, homogeneous billets.

Each billet must conform to rigid Phelps Dodge standards, as well as to the requirements of ASTM and U.S. Government specifications. Strict control is maintained over every phase of the billet-casting operation.

Before melting, the metals to be alloyed are carefully weighed to their correct proportions in the cast billet. Each melt is carefully sampled for chemical and spectrographic analyses which verify the composition of the billet before it is released for further processing.

Throughout the entire tube fabrication—from raw materials to finished product—quality is the keynote. That's why Phelps Dodge tubes are preferred by those who demand the finest . . . the manufacturers and users of heat exchangers and condensers.

1 BILLET-CASTING

(FIRST OF A FIVE-PART SERIES)

Casting shop area in new Phelps Dodge tube mill at South Brunswick, N. J. This mill has the largest copper and copper-alloy tube capacity in the U. S.

Alloy proportions are carefully checked by spectrographic analysis to assure conformance with exact specifications.

ɔuilt into Phelps Dodge
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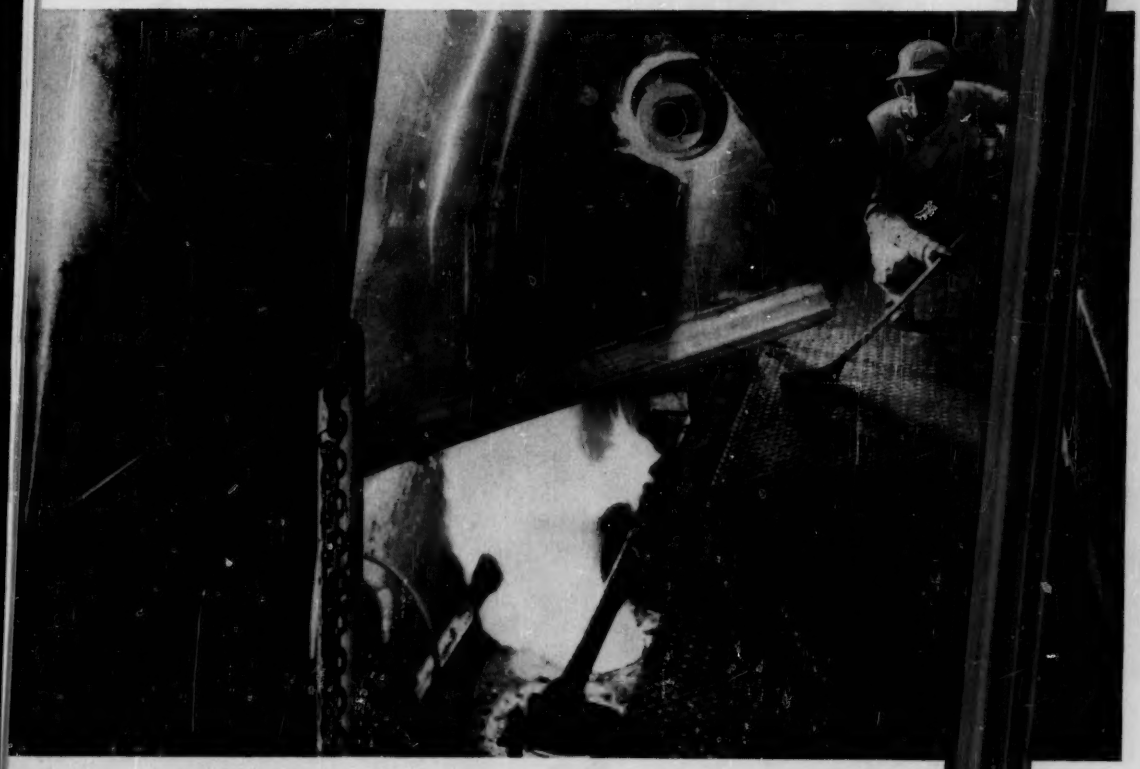

Close-up of casting operation shows molten metal flowing from electric furnace into specially designed molds.

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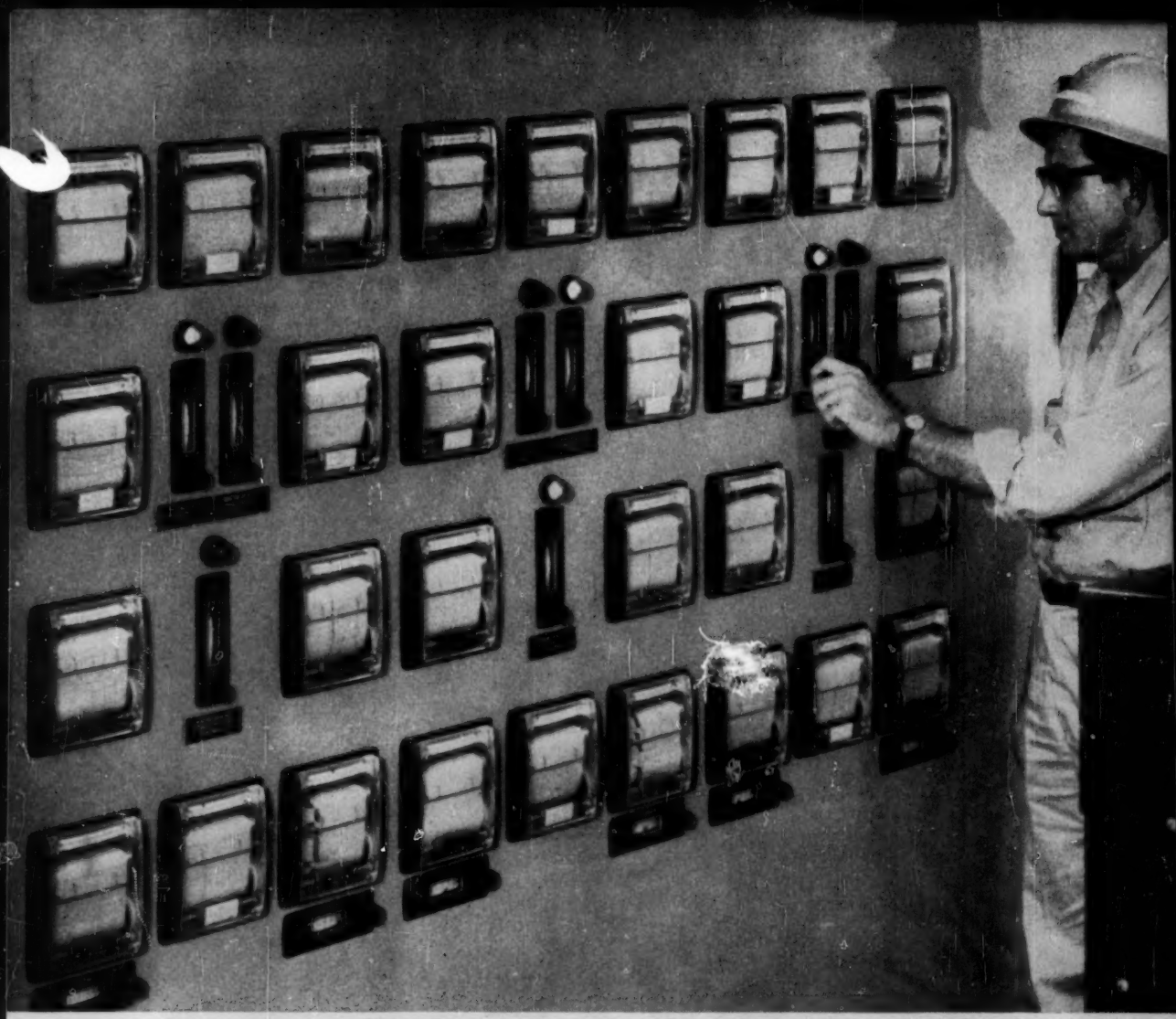

Foxboro Consotrol control panel at W. R. Grace & Co. polyethylene plant in Baton Rouge, Louisiana.

Foxboro Consotrols* help put 50 million pound

"Perfect instrument performance on start-up," reports W. R. Grace & Co.'s

50 million pounds of GREX — W. R. Grace & Co.'s new high strength plastic resin — that's the capacity of their new Polymer Chemicals Division plant in Baton Rouge, La. Instrumentation for the 30 acre, multi-million dollar facility was supplied by The Foxboro Company.

"Our main Foxboro panel was a big help in getting this temperature-controlled process off to a successful start," reports instrument supervisor Al Farris. "Over 95% of the variables on the panel are controlled — many of the key ones are part of cascade control systems. Instrument performance on start-up was perfect."

Grace instrument men like their Foxboro pneumatic Consotrols for other reasons as well: The M/54 Recorder's 4-inch vertical-travel chart . . . the drawer-type pull-out feature of Consotrols . . . the fact that in 18 months of operation not a single Consotrol has needed re-calibration.

Foxboro Consotrol instrumentation includes con-

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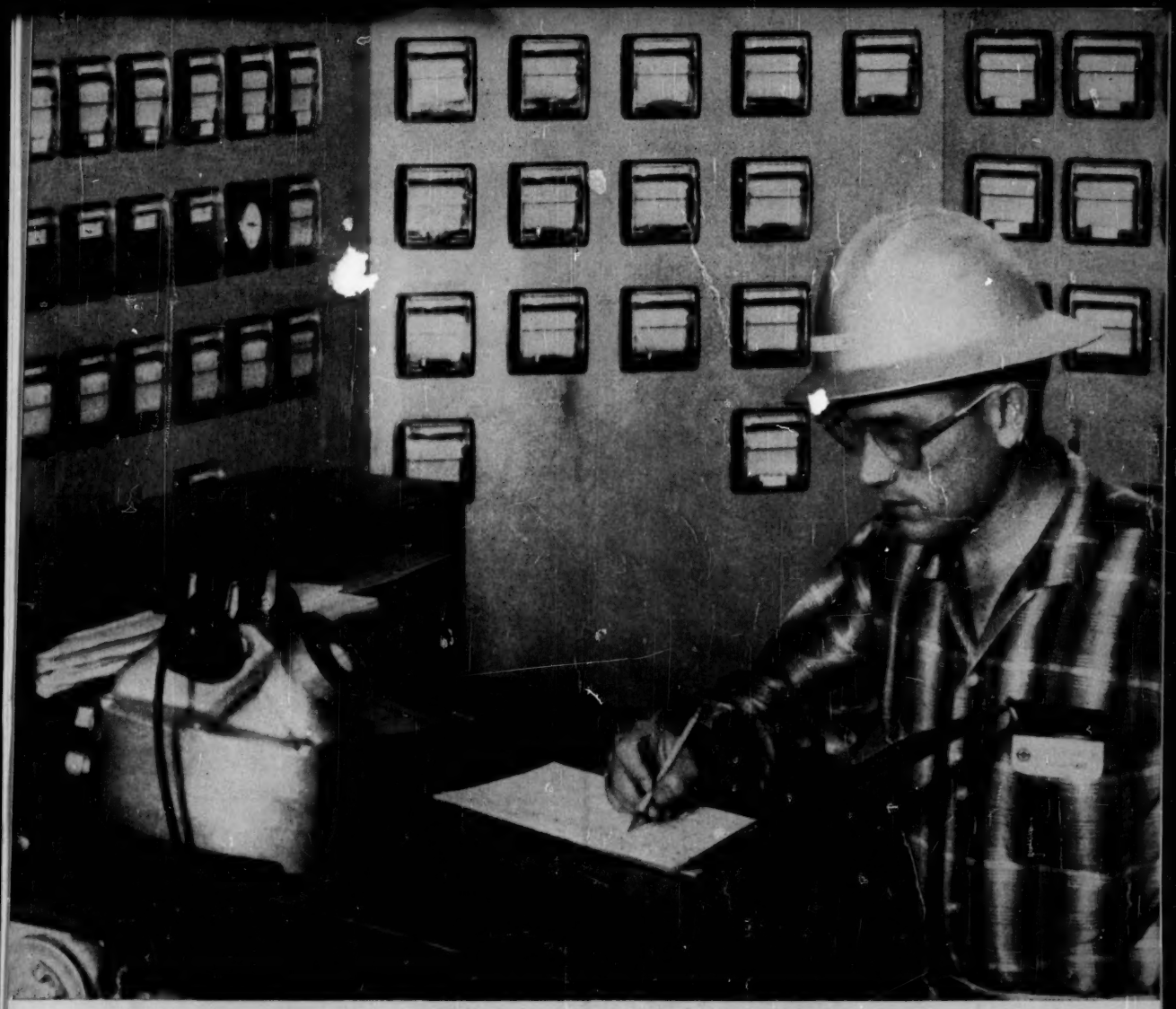

polyethylene plant on stream without a hitch

Polymer Chemicals Division

trol functions for all types of processing requirements — auto-selector . . . cascade and ratio systems . . . automatic batch control. Get the complete story by writing for Bulletin 13-18. **The Foxboro Company, 361 Neponset Ave., Foxboro, Mass.**

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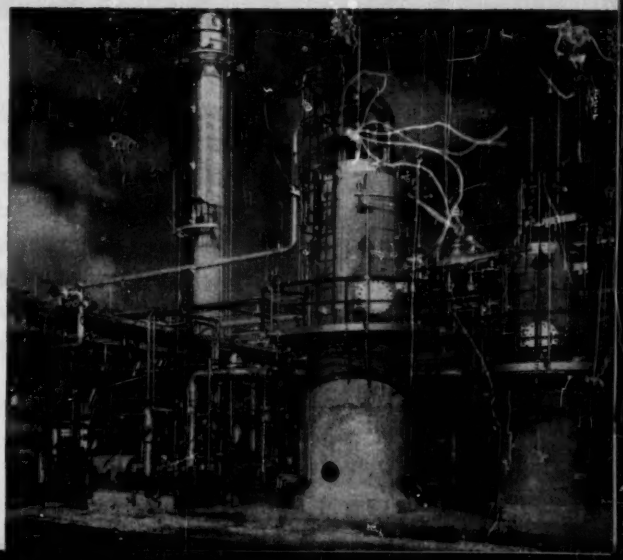
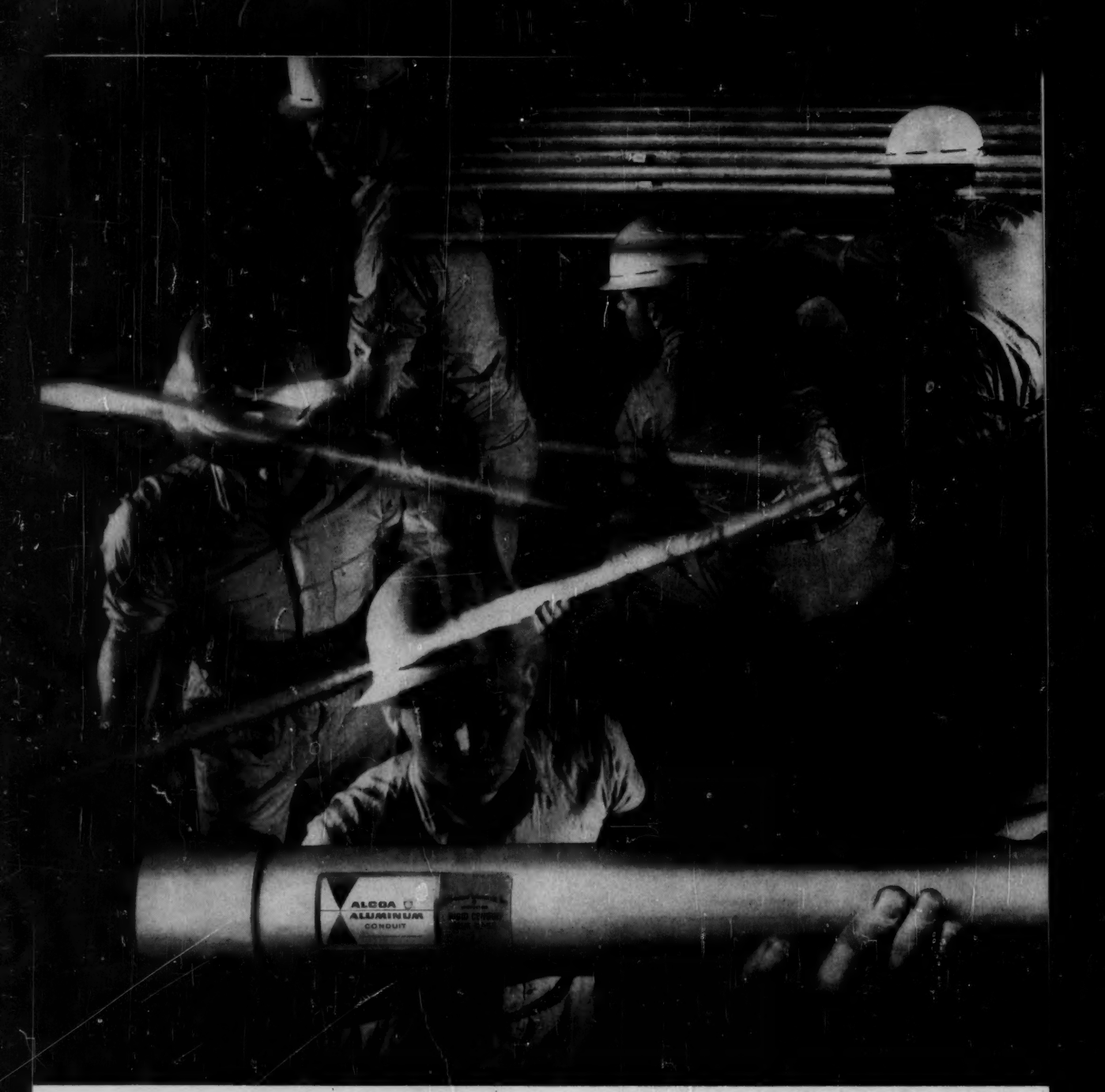
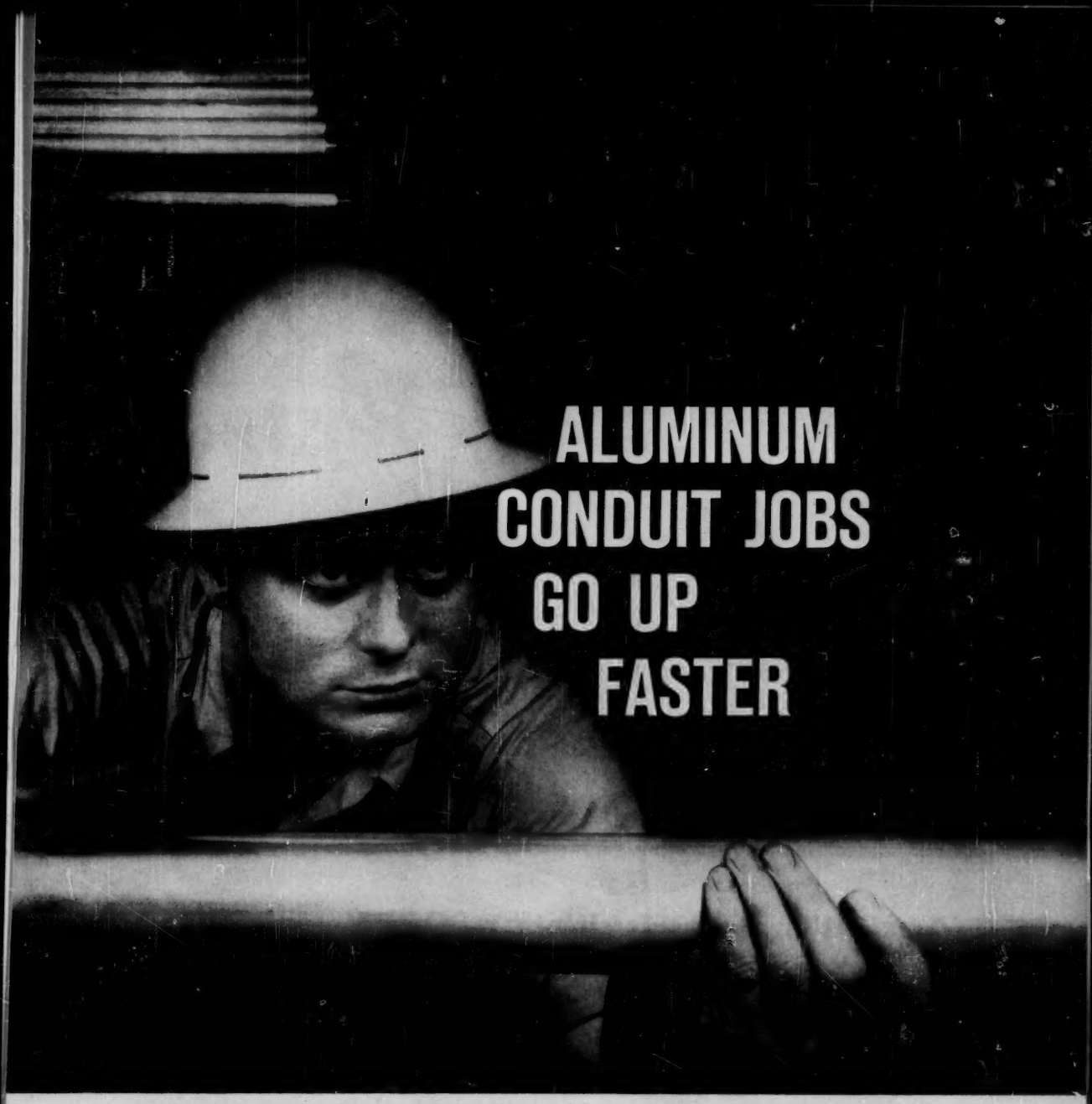


30-acre W. R. Grace & Co. Polymer Chemicals Division plant has 50 million pound annual capacity. First product — new high strength plastic resin tradenamed GREX.



HERE'S WHY:

Light weight—weighs only ⅓ as much as steel . . . **easier to handle** regardless of the job . . . **easy to cut, bend and thread,** and without special tools . . . **competitive in price** for initial savings as well as future savings . . . **corrosion resistance** means no maintenance under normal service conditions . . . **non-sparking** for safer installations . . . no special nonsparking tools required . . . **nonmagnetic** properties mean less voltage drop . . . **good appearance** that lasts and lasts . . . **color coded** for fast, accurate size identification. **Approved by Underwriters' Laboratories, Inc.** . . . and it's **available from local distributor stocks** for fast, dependable delivery.



Aluminum conduit not only makes jobs go up easier, faster and therefore more profitably, but also helps give you a higher quality, longer lasting installation. Why not use aluminum conduit on your next job? Start enjoying all the many advantages which only timesaving, costsaving aluminum conduit can provide. Your local Alcoa or Rome distributor can give you all the facts and figures for any particular installation. Or, write to Rome Cable Division of Alcoa, 2147-M Alcoa Bldg., Pittsburgh 19, Pa.

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Your Guide to the Best in Aluminum Value

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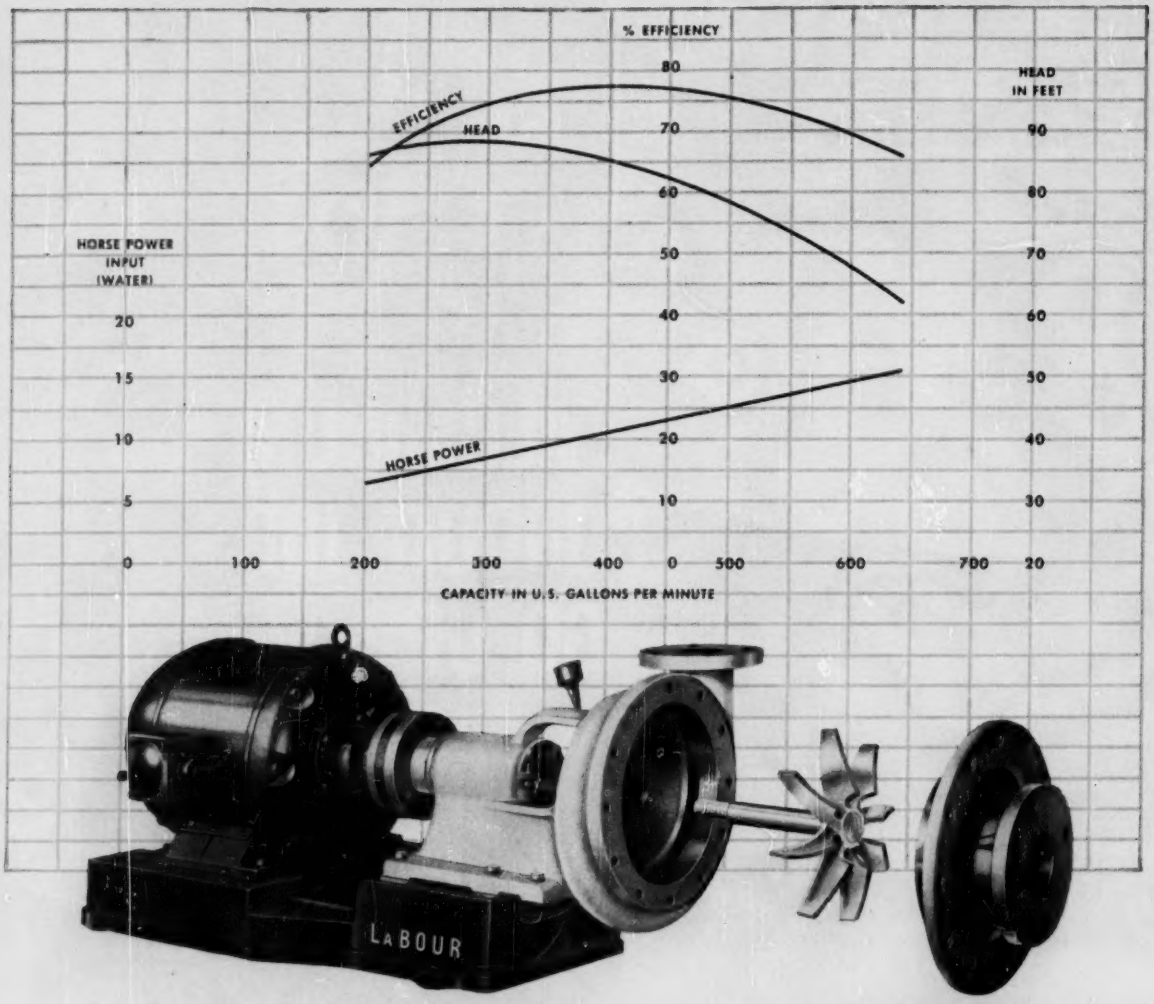


And it's done with an *OPEN IMPELLER*

There's no need to give up the many advantages of open impeller pumps for chemical service, in order to obtain higher efficiency. This curve, the actual record of a LaBour No. 20 Type SQ pump, is typical.

Because the performance of a LaBour pump is not dependent upon close clearances inside the casing, substantial increases in clearances have little effect. That's why, even after long, hard service, LaBour pumps *continue* to deliver relatively high efficiency.

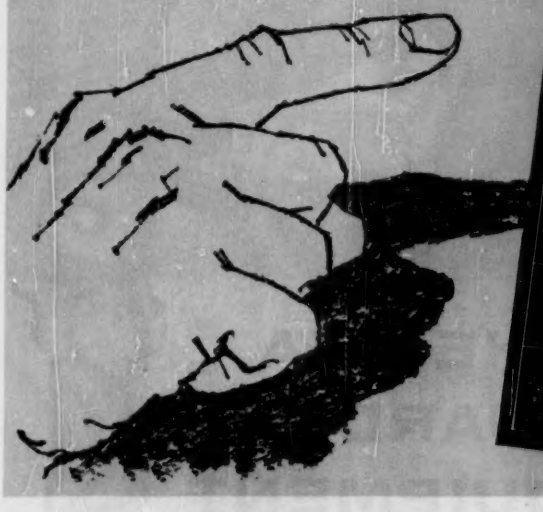
We'll be glad to explain why it's to your advantage to insist on fully open impellers, and to insist on LaBour pumps for efficiency without sacrifice of those advantages. Write us today.

ORIGINAL MANUFACTURERS OF THE SELF PRIMING CENTRIFUGAL PUMP

LABOUR

THE LaBOUR COMPANY, INC. • ELKHART, INDIANA, U. S. A.

Why you can't afford cheap nozzles...



BORE OF NOZZLE IN INCHES	CU. FT. OF AIR PER MINUTE @ 80 LBS. PER SQ. IN.	H.P. REQUIRED TO MAINTAIN PRESSURE
3/8	191	34.76
13/32	225	40.95
7/16	260	47.32
15/32	299	54.42
1/2	340	61.88
9/16	430	78.26
5/8	532	96.82

The chart tells the story.

Any pressure blast nozzle which wears rapidly greatly increases your compressed air bill. For example, when you start with a 3/8" bore nozzle at 80 lbs. blasting pressure, it will pass 191 cu. ft. of air per minute, requiring 34.76 H.P. However, when this nozzle has enlarged only 3/16" to 9/16" bore, you must supply 430 cu. ft. of air per minute to maintain the 80 lb. pressure. And you pay for 78.26 H.P. to develop this volume. And with ordinary nozzles, the difference between 3/8" and 9/16" occurs in only a few hours, or when manufactured abrasives are used, this can happen in a matter of minutes!

Now contrast the minimum guaranteed life of Norton NORBIDE* Pressure Blast Nozzles: 750 hours with silica sand . . . 1500 hours with steel shot or grit! Lined with light, tough Norton Boron Carbide — a compound exceeded in hardness only by the diamond — they maintain high-efficiency abrasive velocity *economically* throughout their life span.

Why blast away your profits with cheap nozzles? Get the most work out of both nozzle *and* air with NORBIDE Nozzles. Available with bores from 1/8" to 3/8"; lengths up to 6". For details write Norton Company, Refractories Division, 500 New Bond Street, Worcester 6, Mass.

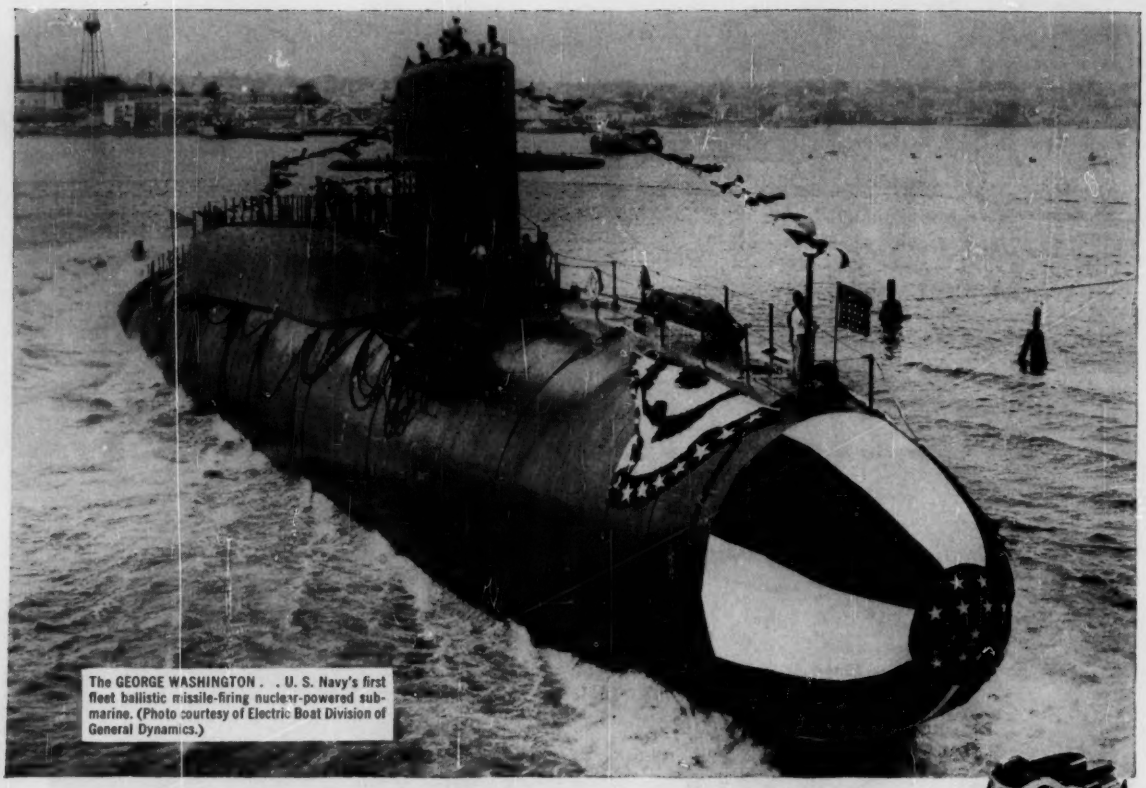
*Trade-Mark Reg. U.S. Pat. Off. and Foreign Countries

NORBIDE Pressure Blast Nozzles cut air costs 10% to 20%.

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

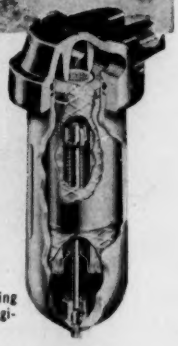
Making better products . . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — BEHR-MANNING DIVISION: Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes



The GEORGE WASHINGTON . . U. S. Navy's first fleet ballistic missile-firing nuclear-powered submarine. (Photo courtesy of Electric Boat Division of General Dynamics.)

EVEN UNDER THE SEA *Fulflo Filters* GUARD PNEUMATIC EQUIPMENT



This standard Fulflo Filter is designed for operating pressures of 4,000 psi. Special models can be engineered for even higher pressures.

The *George Washington* will be the first submarine to fire the Polaris missile from submerged positions at sea. We are proud that Fulflo Filters were selected to protect the pneumatic equipment on this great ship . . . destined to play a vital war deterrent role for the free world.

Fulflo Filters, with patented Honeycomb Filter Tubes, minimize troublesome gumming — remove moisture, oil, microscopic rust, dust, dirt and scale from your air lines. Single-tube models are designed for pressures from 125 to 4,000 psi. Multi-tube models are available for large flow rates or central installations.

CFC Filters also provide micro-clarity for other industrial fluids — liquid chemicals, oils, pharmaceuticals, hydraulic fluids, diesel fluids, plating solutions, water, CO_2 and other gases.

Write for catalog to Department CE

COMMERCIAL FILTERS CORPORATION
MELROSE 76, MASSACHUSETTS
PLANTS IN MELROSE, MASSACHUSETTS AND LEBANON, INDIANA

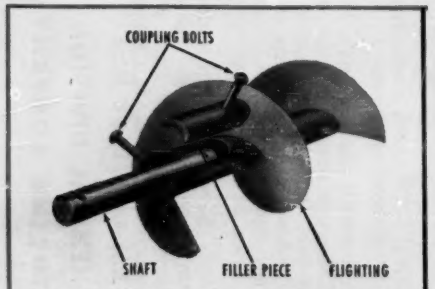
MICRO-CLARITY AT MINIMUM COST

Fulflo FILTERS — *with genuine Honeycomb Filter Tubes for controlled micro-clarity of industrial fluids.*

CFC FILTERS — *Selective filtration of oils • water-oil separators • magnetic separators • pre-coat filters • coolant clarifiers • automatic tubular conveyors.*

How Quik-Link conveyor screws

KNOCK DOWN DOWNTIME



HOW IT WORKS — First, coupling bolts and filler pieces are removed from each end of screw section to be replaced. Then the hanger is unbolted, and entire section lifted from trough.

Only LINK-BELT Quik-Link lets you remove a single section without disturbing other components

Here's how you can side-step a serious production bottleneck. Quik-Link offers the fastest method yet of replacing a damaged screw and putting the conveyor back into service. Just a fraction of the normal time.

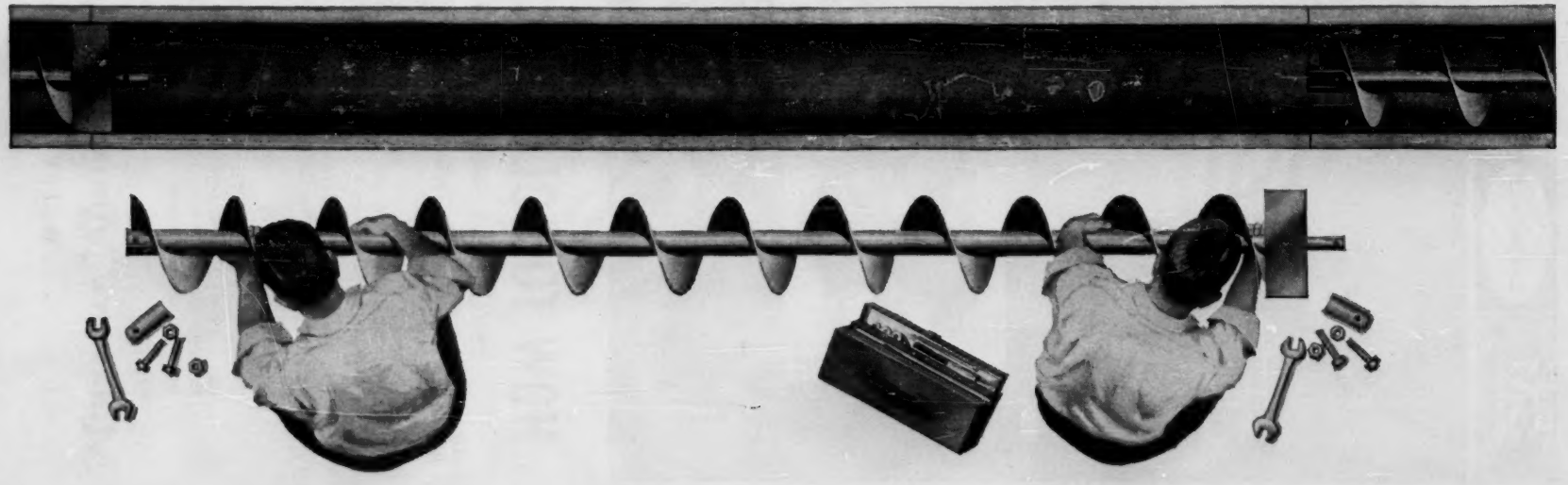
That's why it's time you investigated the "down-time insurance" built into every section of Link-Belt Quik-Link conveyor screws. Your maintenance men become quick-change artists in no time—a wrench and 30 minutes change the damaged screw section and put the conveyor back to work. What's more, there is no need to pull down the entire line . . . no need to disturb other conveyor components.

Quik-Link is just one of a whole group of Link-Belt screw conveyor components that are cutting maintenance and power requirements to the bone. For full facts call your nearest Link-Belt office or authorized stock-carrying distributor. Or write for Book 2989.

LINK-BELT

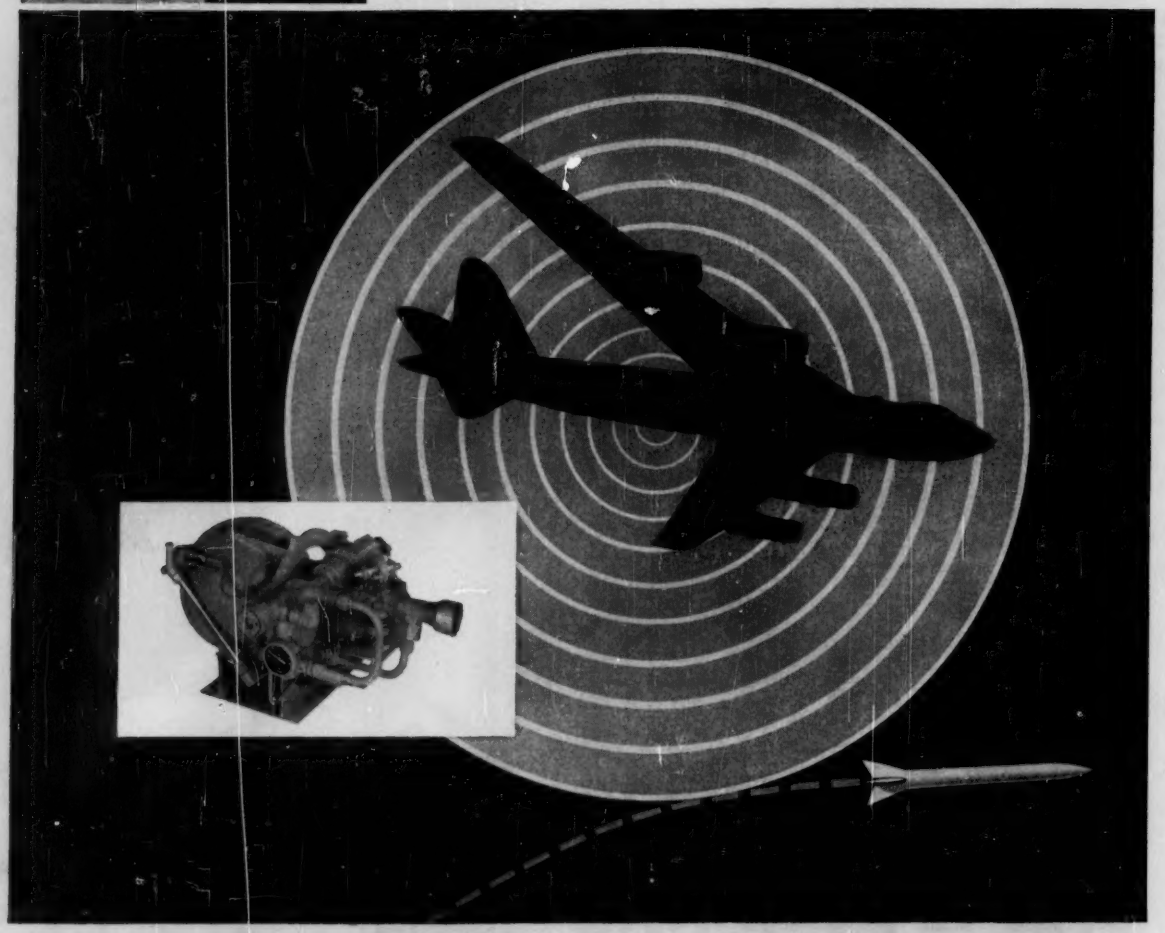
SCREW CONVEYORS 15,239

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.



3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS



HOW TO HOLD A JAM SESSION 8 MILES UP

Vickers active cooling system (inset) uses FC-75 in countermeasures system

The increasing sophistication of electronic countermeasures systems poses many problems. Among them—how to cool vital components at the environmental and operational extremes encountered in sonic and supersonic aircraft.

For the Sperry countermeasures system, a new airborne active cooling system—capable of dissipating 47KW in a 74-lb. package—was developed by Vickers using 3M Dielectric Coolant FC-75.

This most stable of all fluids offered to electronics has high electric strength of 37KV. It is self-healing, and maintains electric strength after repeated high voltage arcing. It pours at —148°F and boils at 212°F at one atmosphere . . . ideally suited for evaporative cooling.

Compatible with most materials, FC-75 is non-corrosive, non-flammable, non-toxic, non-explosive and odorless. It is thermally stable in excess of 800°F, and will not form sludges or gums under extremely rigorous conditions. These properties make it ideal as a coolant.

Investigate the remarkable properties of 3M inert fluids in terms of your own product design, miniaturization and performance problems. For free literature, write to 3M Chemical Division, Dept. KAL-10, St. Paul 6, Minn.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

&

INSTRUMENTS THAT MEASURE AND CONTROL TEMPERATURE, PRESSURE, FLOW, &c., &c., &c.
have established and maintained their reputation for superiority against all competitors
through the years and are in increasing demand. As in the past, it is the unalterable
DETERMINATION OF THE HOUSE TO SEND OUT NOTHING BUT WHAT IS OF
THE HIGHEST POSSIBLE QUALITY

THE HANDIEST GUIDE TO THE VARIOUS AND SUNDRY METHODS PRESENTLY AVAILABLE FOR MEASURING FLOW

It has been our pleasure and profit over the years to aid and assist divers engineers in the estimable task of selecting the one—nay, the *only* device best suited to measuring a given flow. But truly, the years have added, the devices have multiplied, and the task of selection has grown ever more complex. As a result, the "handy" guides, so reminiscent of an earlier day have grown less handy all the time. Let us see how handy we can be.

LESSON I

There are but four major types of flowmeters.

1. VARIABLE-AREA (ROTAMETERS)

2. VARIABLE HEAD (ORIFICES, VENTURIS & CO.)

3. INTEGRATING (TURBINE)

4. OBSTRUCTIONLESS (MAGNETIC)

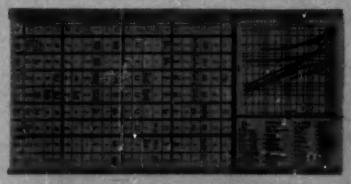
LESSON II

In order to be as handy as possible, we shall limit our discussion of the advantages of the four basic types to a single characteristic benefit.

1. Variable-Area: linear scale
2. Variable Head: flexibility
3. Integrating: accuracy
4. Obstructionless: obstructionless

LESSON III

The lesson to be learned may well be that there is a definite limit to just how "handy" one can be . . . and still serve as a guide. Six pages hold the record at present. We call the guide Bulletin 91-119, but others have called it the first practical map ever published to the land of flowmetering.



LESSON IV

There are those who philosophically oppose all "handy" guides. If you are among that group, we can only state that we make them all . . . every one of the four major types. A call to our technical assistance group will bring you a firm recommendation unencumbered by bias or prejudice.

THE JUSTLY CELEBRATED

MAGNETIC FLOWMETER

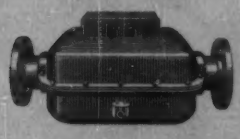
OF FISCHER & PORTER

one of the very best flow instruments ever invented

A clear length of pipe that accurately measures liquid flow by the invisible MAGNETIC FIELD!
SOMETHING NEW! Measures the flow of any liquid with a conductivity of no less than 0.1 micromho per centimeter.
Measures flow IN EITHER DIRECTION and without auxiliary equipment.
Handily provides full scale recording of ANY FLOW RATE from 1 to 30 feet per second at the TURN OF A DIAL

extends the range of accurate flowmetering to heretofore unbelievable limits!

YOUR ATTENTION INVITED!

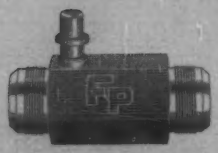


Copyright 1960 Fischer & Porter Company

THE PROCESS ACCOUNTANT'S FRIEND

UNMATCHED

FOR ACCURACY



There is a reason why the turbine meter is called the accountant's friend. For accuracy over a wide range of flow it knows no equal. As a billing, accounting, or computer input meter it is *non pareil.*

Do You Ask Why?

Each and every revolution of the bladed rotor signifies the passage of a definite unit of fluid volume with an electrical pulse. The total number of counts—or rotor revolutions—is proportional to total volume of fluid passing through the meter in a given time period.

It Is A Friend To All

The selfsame accuracy, reliability, convenience, and compactness which have endeared the Fischer & Porter turbine meter to the arbiters of process economics have made it the meter of the missile and jet man as well. Few indeed are the test stands that do not rely on the turbine meter for critical flow information.

The Fischer & Porter Turbine Meter

Like other F&P meters it is characterized by a perfection of design and manufacture that lifts it from the commonplace and sets it apart in every respect. A thorough study of pertinent data will assure you that this is no mere boast. We shall gladly aid you in such study to the full extent that life and limb permit, if you will but notify us of your interest.

This company, by purchasing the very finest raw glass of the proper composition and reforming it over mandrels of unexcelled strength, durability, and precision, on machines of our own design, and by calibrating and testing them to perfection, are enabled to offer the best

of an unsurpassed excellence at the lowest market rates. The long experience of the present management of the company, and the enviable reputation they have established for F&P FLOWRATORS are deemed a sufficient guarantee that purchasers can at all times depend upon receiving flowmeters unsurpassed by any others for accuracy and dependability.

state your pleasure, gentlemen!

To better acquaint our far reaching public with the BENEFITS and ADVANTAGES of our products we have caused to be printed handsome booklets for the general edification. We will gladly post to you a selection of these works upon your application. Make a selection at your leisure from the list below. Sign your name and address in the generous space provided, and send it to us. We are your obedient servants in this as in all other matters.

____2700 Variable-Area Flowmeter
____Variable Head Meter
____Turbine Meter
____Magnetic Flowmeter
____"How To Select Flowmeters"
____"Instruments Available from Stock"

NAME: TITLE:

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Fischer & Porter Co., Hatboro, Pa. Dept. C

These MANUFACTURING AFFILIATES carry Fischer & Porter engineering designs to the far corners of the earth: FISCHER & PORTER LTD., WORKINGTON, CUMBERLAND, ENGLAND • FISCHER & PORTER G.m.b.H., GROSS-ELLERSHAUSEN, BEI GOTTINGEN, GERMANY • FISCHER & PORTER N. V., KONEETWEG 11, THE HAGUE, NETHERLANDS • FISCHER & PORTER Pty. LTD., 184 HANNA ST., SOUTH MELBOURNE, VICTORIA, AUSTRALIA

HOW *HERCULES* HELPS...

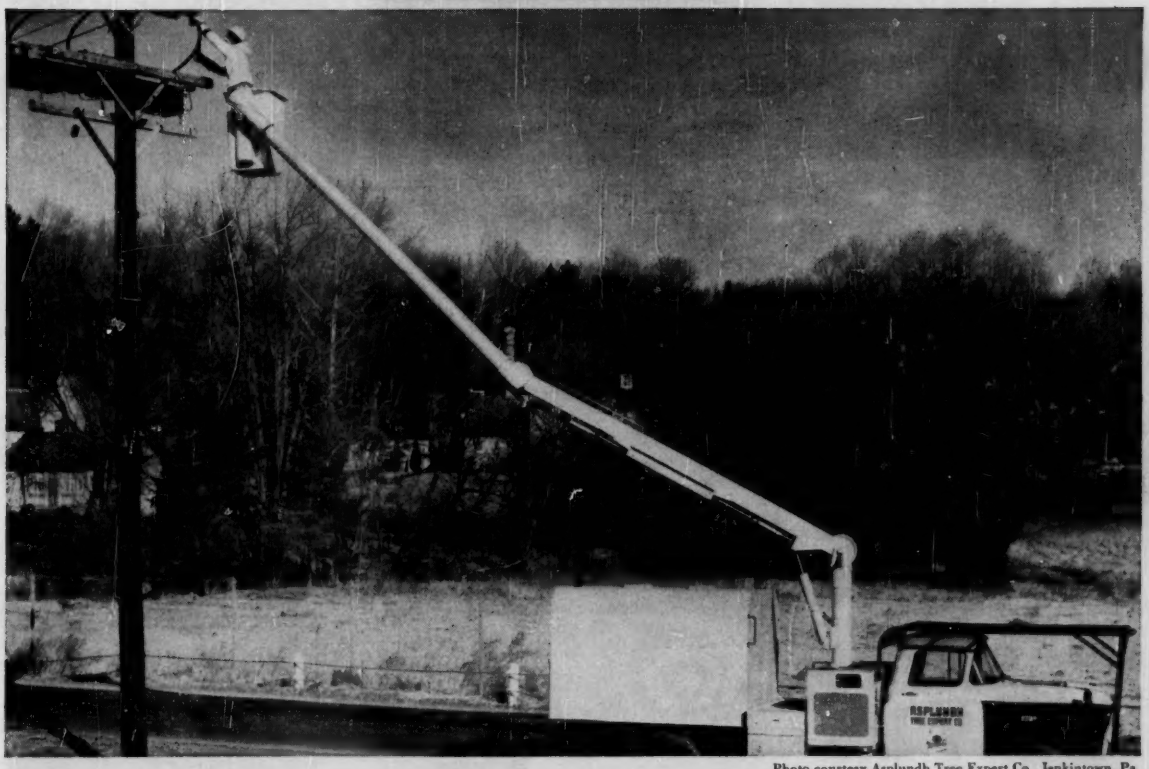
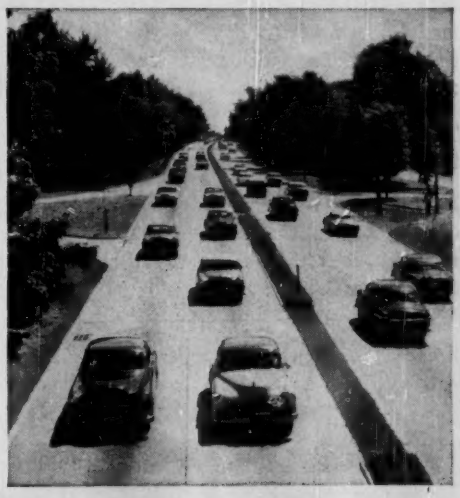


Photo courtesy Asplundh Tree Expert Co., Jenkintown, Pa.

MEN OVER THE WIRE—Spiralloy®, the filamentwound glass fiber-reinforced plastic material made by Hercules, is being used for booms on truck-mounted cranes of utility companies and tree surgeons. Since it is a nonconductor of electricity, Spiralloy is particularly well-suited for this application. Lighter than aluminum and stronger than steel, it has unmatched high-strength-to-weight ratio. Spiralloy-wound cylindrical structures also are gaining acceptance in such fields as missiles, boats, pipe, and storage tanks.

INCREASE SHOE LIFE—A new Hercules material now goes into specially impregnated leather shoe soles that actually "breathe" and have many times the wearability of leather soles. Developed in cooperation with the U. S. government, this product has already proven itself in many types of footwear.



MAKE DRIVING ECONOMY—Among the many Hercules items that go into your automobile is Dalpac® 4, Hercules di-tert-butyl-p-cresol. This antioxidant is added to gasoline at the refinery to inhibit gum formation, stabilize color and help maintain engine cleanliness. It means more trouble-free miles of driving for you.

HERCULES

HERCULES POWDER COMPANY
INCORPORATED
900 Market Street, Wilmington 99, Delaware

CHEMICAL MATERIALS FOR INDUSTRY

G59-7

. . . in wet dust control

NEW DUCON DYNAMIC WASHERS

RECOVER DIFFICULT DUSTS EFFICIENTLY AND ECONOMICALLY

Ducon UW-4 Dynamic Wet Dust Collectors have added a new dimension in dust recovery. They have replaced, with outstanding success, many more costly and less effective dust collectors in the recovery of "difficult" materials, such as fine and abrasive dusts in kilns, rotary driers and other applications.

The UW-4 Washers are also ideal for high loading conditions where maximum efficiency is desired.

Ducon UW-4 washers offer other unique advantages, including constant air capacity, low water consumption and rugged construction. They are self-cleaning and fire and explosion proof.

For complete information write for Bulletin W-7456.

DUCON — DUST CONTROL SYSTEMS AND EQUIPMENT

the name in DUst CONtrol

THE Ducon COMPANY INC.
147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK

Canadian Branch:
THE DUCON COMPANY of CANADA, Ltd.,
1131 Pettit St., BURLINGTON, ONTARIO

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

The customer who thought he got something special

A Gulf Coast oil refiner was in a hurry to build a new catalytic platformer. He needed a special analysis of seamless steel tubing—delivered from the mill in just the exact size and length. But, the refiner was afraid he wouldn't get the steel on time.

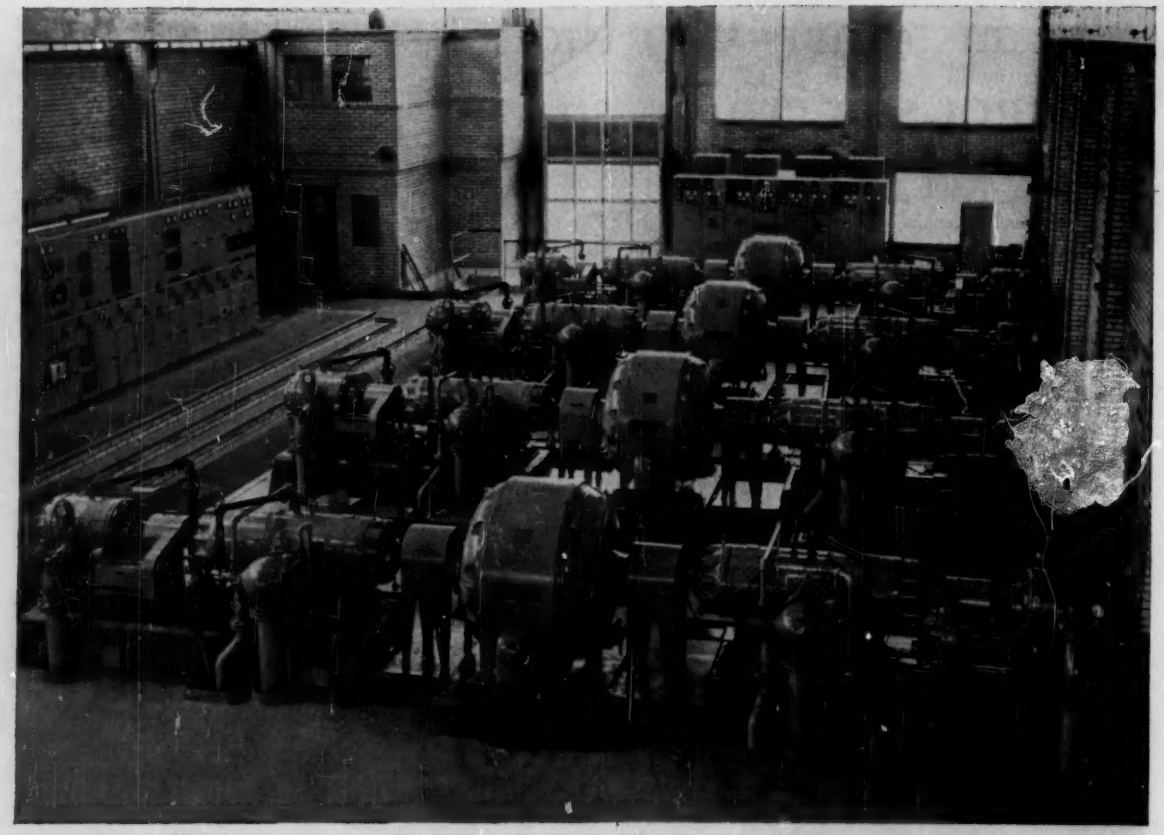
A team of Timken Company experts tackled the problem. They got the steel out on time—so fast that the refiner thought he received special treatment.

And he did—the very same special, individual treatment we're geared to give *every* customer—and do!

This order was routine for our team of metallurgical-production-operating people. Special jobs are right down their alley because they have the know-how and the facilities. You can call ours a tailored operation—but it's really more. The steel was babied all the way. Every modern quality control device kept an eye on the steel all through the melting, rolling, piercing, finishing. It passed every inspection for surface, size and quality and there wasn't a minute's delay. That's the kind of special treatment that's made the Timken Company a leading producer of special quality fine alloy steel.

If you want your steel to receive special treatment, give your next order to the Timken Company, where *every* order is special. And for help in solving your steel problem, consult our metallurgists. They've probably solved a problem similar to yours dozens of times.

The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*



Eight 1664 cfm Fuller rotary units compressing to 120 psig in tandem sets to four 700 hp electric motors. Compressor plant supplies 13,200 cfm load to oil refinery—for air tools, machinery, and other pneumatic uses.

HOW FULLER ROTARY COMPRESSORS SAVE SPACE – CUT OPERATING COSTS,... at major eastern refinery

To save valuable space in the compressor plant, a large eastern oil refinery installed eight two-stage Fuller rotary air compressors—using a unique drive system. Because of the simple direct-drive through flexible couplings permissible with Fuller rotaries, the refinery was able to drive dual sets of compressors by single, 700 hp. electric motors.

While this means savings in space, the rotaries are also operating with cost-cutting efficiency.

In more than two years of service, these rugged compressors have required no down-time for repairs!

Simple design, rugged construction and precision manufacture are the "secrets" of Fuller rotaries' dependability. The only moving parts are rotor, blades and bearings. There is no reciprocating action—hence no vibration. Smooth, quiet operation permits installation on light-weight foundations, on upper floors—saving in weight, bulk and cost of installation.

For full details on the maintenance-free economy and high performance of Fuller rotaries, write today for comprehensive, illustrated Bulletin C-5A. C-343 1346

Fuller
...pioneers in harnessing AIR

FULLER COMPANY
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Subsidiary of General American Transportation Corporation
Offices in principal cities

FULLER COMPANY GENERAL

ECO ENGINEERING NEWS

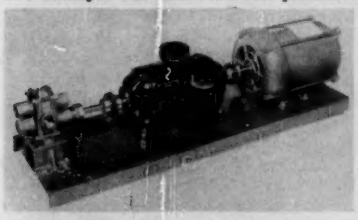
the big name in small pumps for the process industries

Pumping Notes

GEARCHEM Pumps Solve Catalyst Metering Problem

Hanford Nuclear Operations, Richland, Washington, had a real problem in metering, at variable flow rates, a viscous catalyst used to cure silicone rubbers. Impulse diaphragm pumps, as normally used to move this hesitant mass, gave undesirable slug type delivery with unavoidable irregular volumetric yields.

The problem was solved with Eco GEARCHEM pumps in Hastelloy* construction and with Hastelloy gears, driven by Vickers variable speed transmission. These pumps, supplying linear, low capacity flows, provided the essential, dependable metering of the catalyst for uniform end product.



From Viscous Catalysts To Thinner-Than-Water Solvents

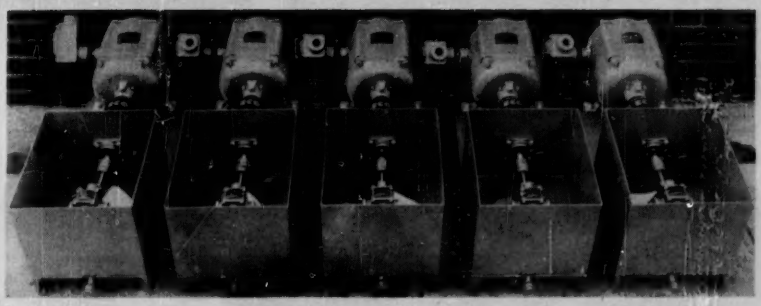
Thus, the GEARCHEM Pump proves its great versatility. The requirements of U.B.S. Chemical Company, Cambridge, Mass., were the exact reverse of Hanford Nuclear Operations outlined above.

Here the problem was the exact metering of several thinner-than-water media into a reactor. Suction lift also was required at low rpm.

Several Eco GEARCHEM pumps with Vickers variable speed drives were employed with Rotometers, permitting accurate adjustment of flow rates of each media. The pumps were equipped with TEFLON† gears and floating wear plates, compensating for expansion and contraction and normal end wear of the TEFLON gears. This construction assures sustained high vacuum for necessary suction lift and reproducible accuracy in constant flow metering within plus or minus one per cent.

Battery Builders Choose ALL-CHEM

DELCO-REMY, Division of General Motors, Anderson, Indiana, long time users of Eco ALL-CHEM Pumps for their non-segmentated, non-aerated flows in handling mixtures of phenol, sulphuric acid and water — have recently reordered for their Olathe, Kansas operation. These ALL-CHEM Pumps are made of Carpenter 20 stainless steel with du Pont TEFLON Impellers, bearings and packings.



Immersion Techniques Provide Ultimate Seal

Nothing better illustrates low cost engineering for ultimate requirements with Eco Pumps than the five GEARCHEM units shown above. This is a repeat order from a customer that has used Eco GEARCHEM Pumps, submerged in an inert liquid, to pump against vacuums in the 20 to 50 micron range in the distillation of aromatics.

Immersion techniques meet operational requirements impossible to accomplish with packed stuffing boxes or even the most complicated mechanical seals. They accomplish not only positive exclusion of air from the pumped media, but also safe disposal of hazardous stuffing box leakage into a suitable immersion medium.

High Praise for Zirconium Pump

Typical of many highly favorable comments from users of Eco zirconium GEARCHEM Pumps are the two following:

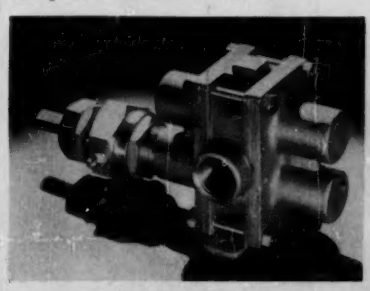
Coast Manufacturing & Supply Co., Livermore, Cal.: "You will probably be interested in knowing that before we installed our Eco pump, we tried two other makes of acid pumps and both failed.

"Our Eco Series 400 GEARCHEM Pump with zirconium body and TEFLON gears has, to date, given us trouble-free, dependable service." (Put in service February 1959, pumping muriatic acid.)

Stauffer Chemical Co. This company reports many disappointing experiences with various makes of pumps to handle methyl sulphonyl chloride until they finally settled on Eco zirconium GEARCHEM Pumps for this problem job. Gears supplied were of TEFLON and shafts of Tantalum.

Petroleum Alkylation Employs Many Monel Pumps

Several refineries have purchased Eco GEARCHEM Pumps in Monel, with carbon bearings and carbon wear plates, metallic gears of Hastelloy C, and grease-sealed, lantern-ring stuffing boxes. These pumps are handling mixtures of hydrocarbons with hydrofluoric acid in various concentrations and viscosities at pressures to 100 psi and temperatures to 300° F.



ECO Products for Handling Corrosive and Hazardous Processing Fluids

ALL-CHEM® Rotary Pumps
MINILAB® Rotary Pumps
GEARCHEM® Gear Pumps
CENTRI-CHEM® Centrifugal Pumps
PUMPMOBILE® Portable Pumping Units
GEAR-VAC® Valves
CHEMICAL DISPENSING VALVES
Factory Mutual Approved

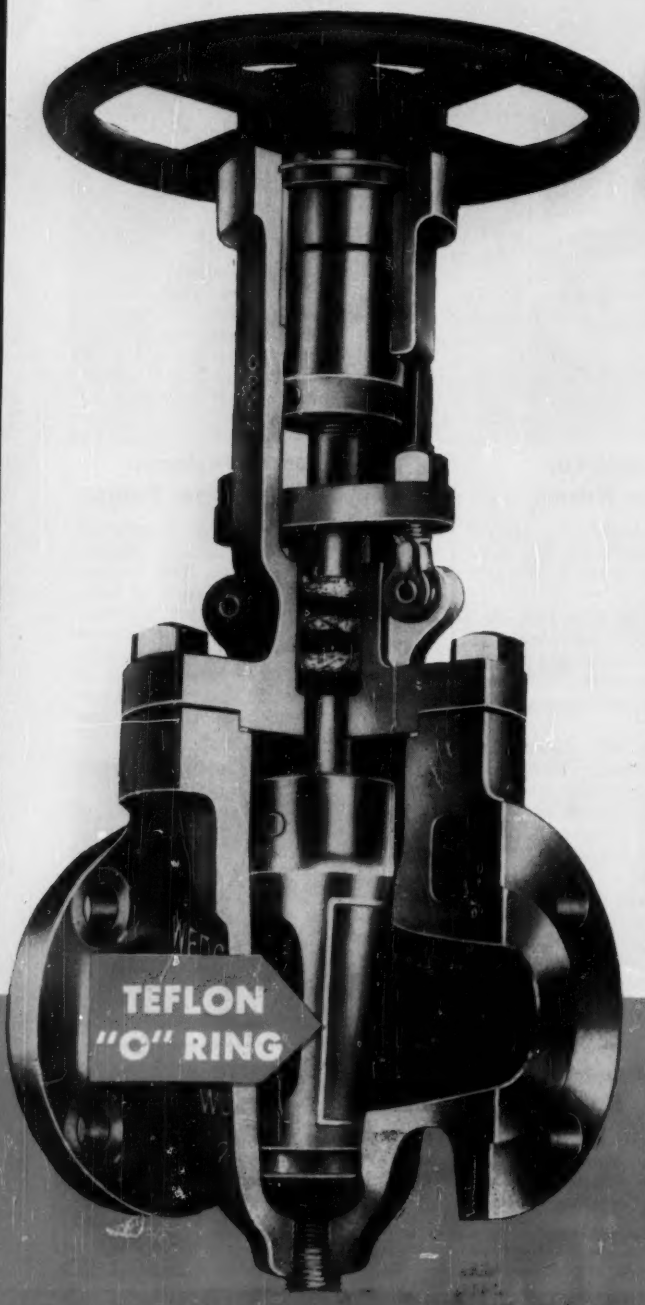
Ask for literature on any or all of these ECO Products

*Union Carbide Trademark. †du Pont Trademark.

ECO ENGINEERING COMPANY · 12 New York Avenue · NEWARK 1, N.J.

BIGGEST MONEY SAVER

In The Valve Industry!



You're familiar with the expense involved in the lubrication of plug valves — the high monthly cost of man hours, grease and equipment, or of a lubrication service. The contaminating influence of the lubricant is also a constant hazard. Not to mention the sticking and leakage that occur when lubrication of a particular valve is overlooked.

These are some of the reasons why Stockham's Wedgeplug "O-Seal" Valve is rapidly replacing lubricated valves in general purpose services everywhere.

The other reason is, simply, that the non-lubricated "O-Seal" equals or betters the performance of any lubricated valve — without costing a cent for maintenance.

Two Teflon† "O" rings in the plug provide absolute shut-off — shut-off that remains permanently "bubble-tight" on both the upstream and downstream seats. Thus, the "O-Seal" provides double-block and bleed in most services. The "O-Seal" has proven itself absolutely leakproof on hundreds of services.

Flawless machining of metal seats provides shut-off in case of fire — double seating for double *safety*. And the "O-Seal" is *guaranteed not to stick.*

Call your Stockham Distributor or Sales Representative now, or write Stockham for complete details about how you'll save money — from now on — with

Stockham's NON-LUBRICATED Wedgeplug* "O-Seal" Valve

Complete ranges of sizes and types available.

†Teflon, Dupont Trademark *Patented

WEDGEPLUG VALVE COMPANY
DIVISION OF

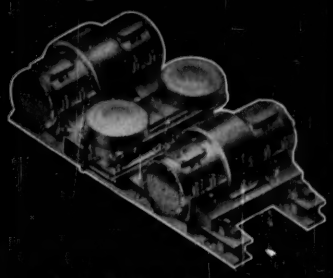
STOCKHAM
VALVES *and* FITTINGS

General Offices and Plant
4000 North 10th Avenue Birmingham 2, Alabama
CAST IRON-MALLEABLE AND DUCTILE IRON PIPE FITTINGS — BRONZE,
CAST IRON, DUCTILE IRON, CAST AND FORGED STEEL VALVES
Sold Only Through Distributors

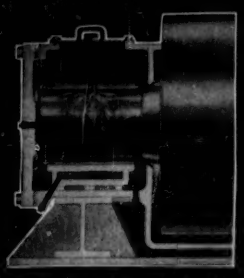
Traylor

ROTARY KILNS

Feature single support type roller bearings for perfect alignment:



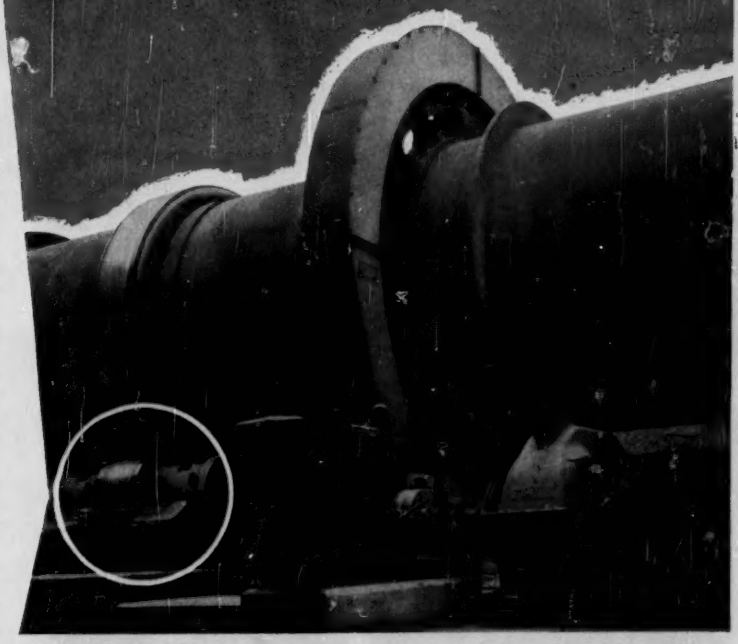
Standard roller support made with cast steel or forged steel rollers mounted on forged steel shafts.



Oil reservoir and oiling mechanism distributing oil over the shaft in a Traylor single support roller bearing.

Traylor-made ROTARY KILNS

demonstrate engineering leadership!



Hundreds of Traylor Kilns in use today reflect the sound design and high standards of Traylor engineering leadership. Put your machinery problems in the hands of experienced Traylor engineers for a sure way to a quick and efficient solution. Write for Bulletin No. 1115.

Traylor

TRAYLOR ENGINEERING & MANUFACTURING, *division of* FULLER COMPANY

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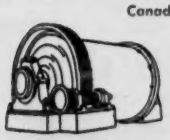


BALL MILLS

ROTARY KILNS

APRON FEEDERS

PRIMARY GYRATORY CRUSHERS

JAW CRUSHERS

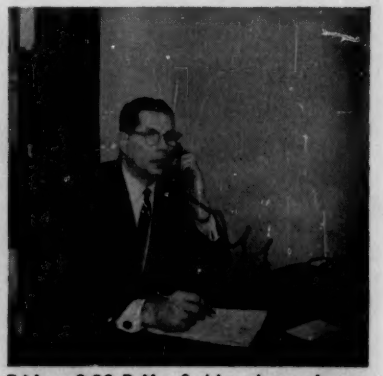
SECONDARY GYRATORY CRUSHERS

Refinery licks tough heat exchanger crisis with emergency tube service

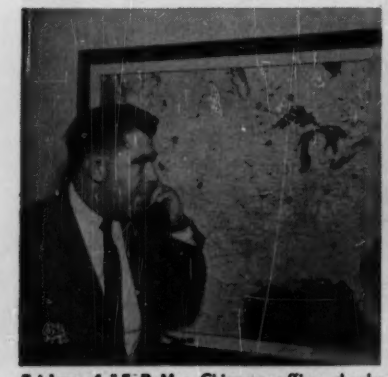
A sudden tube failure at the Pure Oil Company's Refinery in Lemont, Illinois, recently put Bridgeport's condenser tube service to the test. The failure hit on Friday afternoon—just before business slowed down for the week end. Faced with the prospect of costly equipment down time, the refinery called Bridgeport's Chicago office to find out how fast new tubes could be supplied. Here's a round-the-clock story of how the emergency was licked.

Friday, 2:30 P.M.: Salesman from Bridgeport's Chicago office learns that Pure Oil needs 900 Admiralty condenser tubes, and fast.

Friday, 3:00 P.M.: Salesman contacts our Bridgeport, Connecticut, mill and is informed that order can be delivered to Pure Oil Refinery in one week.

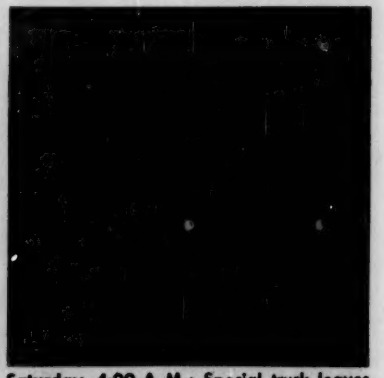


Friday, 3:30 P.M.: Sudden change in customer's needs makes immediate delivery of tubes imperative.

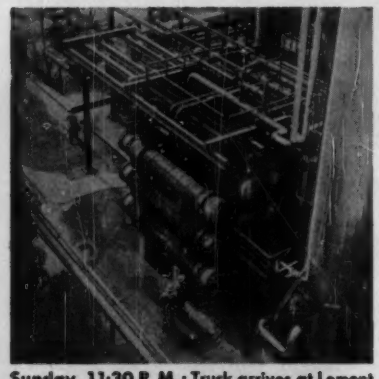


Friday, 4:15 P.M.: Chicago office checks through coast to coast network of Bridgeport warehouse stocks. Locates tubes at Beaumont, Texas.

Friday, 4:30 P.M.: Special night shift at Beaumont is put on job to cut tubes to special lengths and pack for shipment.



Saturday, 4:00 A.M.: Special truck leaves Beaumont, Texas, with order for Pure Oil Refinery in Lemont, Illinois.



Sunday, 11:30 P.M.: Truck arrives at Lemont Refinery with 900 Admiralty tubes, ready for repair work to start Monday morning.

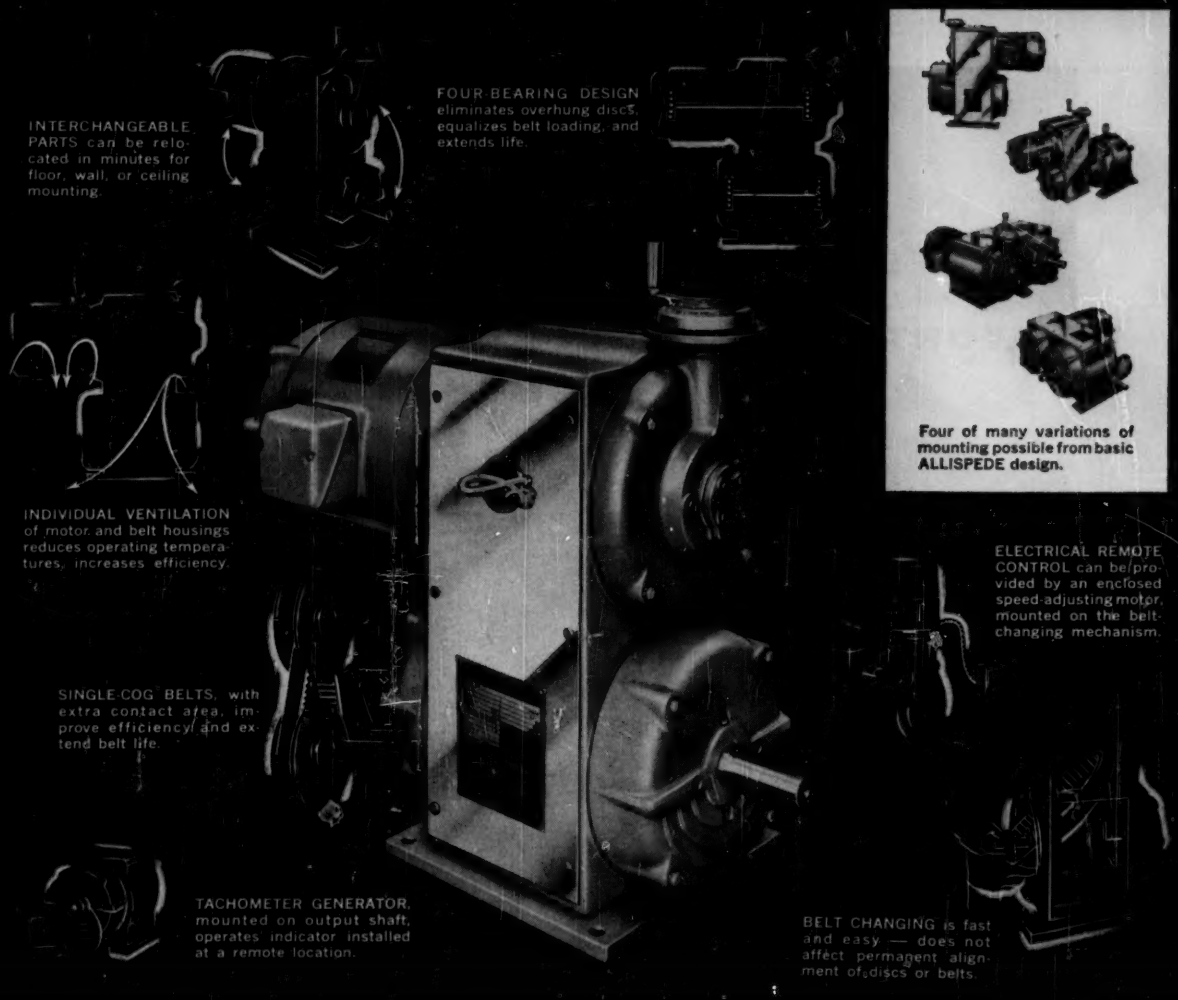
While emergencies like this don't happen every day, they do prove dramatically that Bridgeport's customer service can come to the rescue. When we talk about fast service from our network of sales offices and warehouses, we mean it. Let us tell you more about our service on your condenser and heat exchanger tube needs, whether they're emergencies or normal deliveries. Call your nearest Bridgeport Sales Office, or get in touch with us direct.

Write for your free copy of Bridgeport's Condenser and Heat Exchanger Tube Handbook. Address Dept. 5010.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut • Sales Offices in Principal Cities

Specialists in Metals from **A***luminum to* **Z***irconium*


INTERCHANGEABLE PARTS can be relocated in minutes for floor, wall, or ceiling mounting.
FOUR-BEARING DESIGN eliminates overhung discs, equalizes belt loading, and extends life.
INDIVIDUAL VENTILATION of motor and belt housings reduces operating temperatures, increases efficiency.
SINGLE-COG BELTS, with extra contact area, improve efficiency and extend belt life.
TACHOMETER GENERATOR, mounted on output shaft, operates indicator installed at a remote location.
ELECTRICAL REMOTE CONTROL can be provided by an enclosed speed-adjusting motor, mounted on the belt-changing mechanism.
BELT CHANGING is fast and easy — does not affect permanent alignment of discs or belts.

Four of many variations of mounting possible from basic ALLISPEDE design.

Let's look at the features of the ALLISPEDE* Drive

New Louis Allis drive offers accurate control—maximum belt life—long-run economy—low-cost versatility—ease of installation

Here's a drive so easily adaptable to changing physical and operating needs that it obsoletes obsolescence. You can relocate components — add or remove attachments and controls — in the field, in minutes.

Its *all-new* design improves performance and efficiency. Inspection, servicing, and belt-changing are a snap. Furthermore, maintenance is almost nil.

As for versatility — there's an Allispede to meet whatever mechanical drive requirement you have. Sizes up to 30 hp, output speeds from 1 to 10,000 rpm, and speed ranges up to 8:1. Motors can be open, drip-proof, enclosed, or explosion-proof—with ventilated or enclosed belt housings — for foot, P-base, C- or D-flange mounting on your machine.

Allispede is available with parallel shaft, or right-angle, integral speed reducers; special shaft extensions; integral magnetic brakes; electrical or mechanical remote control, and other modifications.

Interested? Contact your nearby Louis Allis District Office or write to The Louis Allis Co., 447 East Stewart Street, Milwaukee 1, Wisconsin, for a copy of Bulletin 3600.

*Allispede is a trademark of The Louis Allis Company.

LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

ASD-133

the **WALWORTH CUSTOMER** *wants* **PLASTIC VALVES** *and* **FITTINGS** *that can't corrode ...here's how he gets them*

When the Walworth Customer is faced with the control of corrosive fluids, he looks at dozens of plastic valves and checks them for himself. He demands answers to questions like these: Can this valve corrode? Is it toxic? Is it non-aging? In Walworth PVC Valves and Fittings, the Walworth Customer finds his answers. Not only is PVC nontoxic and non-aging, – it *can't* corrode. *All* parts are made of plastic. Valves and fittings have high burst strength. Given those facts the Walworth Customer buys.

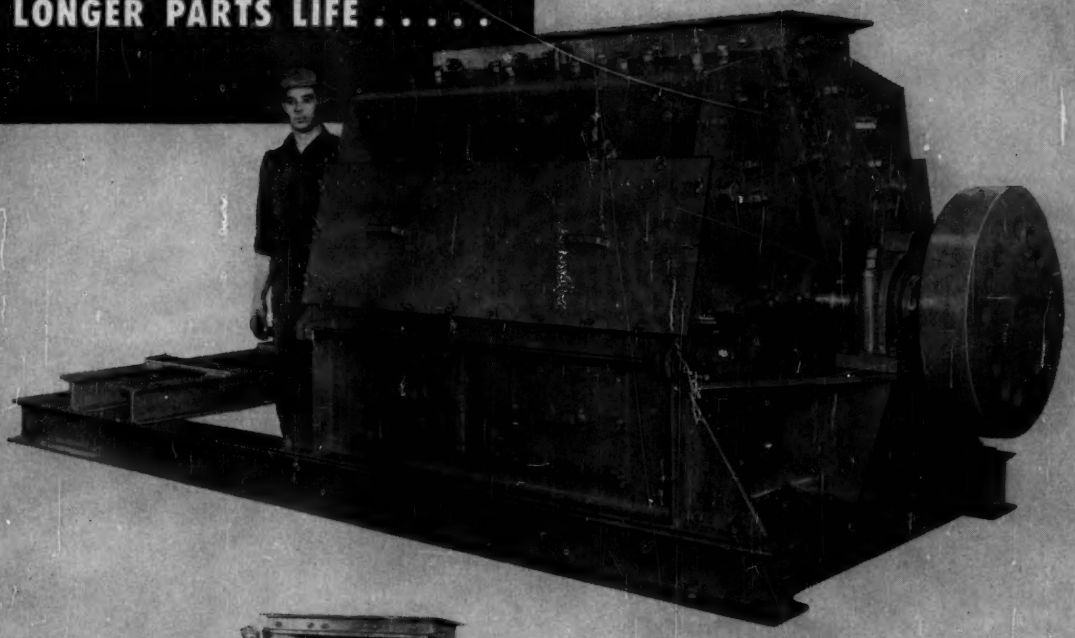
That may be the way you like to buy valves, too. If you insist on knowing about materials, workmanship and high quality, we'd like you for a Walworth Customer, too. For the newest literature on the complete line of PVC Valves and Fittings, get in touch with your Walworth Distributor.

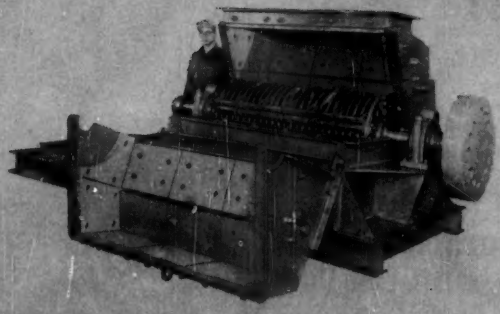
Or write **WALWORTH** *750 Third Avenue, New York 17, N. Y.*
DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

WALWORTH SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO. M&H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING & WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.

NEW DUAL "2-POINT" ADJUSTMENT INSURES MORE UNIFORM GRINDING, LONGER PARTS LIFE . . . . .

WILLIAMS *Reversible* HAMMER MILLS





Williams Reversible Hammer Mill with cover open.
Note these features:

- Super-strong reinforced steel plate frame
- Renewable wear-resistant manganese steel liners
- Heavy duty oversize forged steel rotor shaft
- Anti-friction self-aligning roller bearings in dust-tight housings
- Complete accessibility to interior for quick parts changing

It's another Williams "first"—features not available in other hammer mills—that now makes it possible to maintain the original close clearances of *both* grinding plates *AND* cage sections against the rotating hammers. This easy-to-make "2-point" adjustment, in the most critical grinding area inside the hammer mill, gives absolute assurance of consistently uniform product quality.

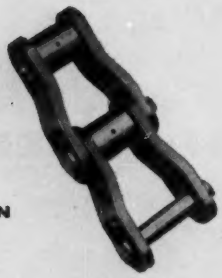
In addition to the advantages of the Dual "2-Point" Adjustment, a Williams Reversible Hammer Mill substantially lowers upkeep expense by cutting hammer cost. Hammers can be operated in one direction today and another tomorrow simply by installing a simple reversing switch on the driving motor. Manual reversing of hammers no longer necessary. Grate bars also last longer. The double set of reversible manganese breaker plates, which last twice as long as other types, give four times the service! Maintenance and downtime are cut 50% or more.

Get all the facts about the hammer mill with *ALL* the top features.

WILLIAMS PATENT CRUSHER & PULVERIZER CO. • 2706 N. Ninth St. • St. Louis 6, Mo.

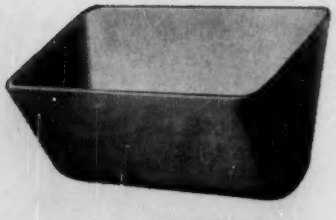
WILLIAMS
CRUSHERS GRINDERS SHREDDERS
Oldest and Largest Manufacturers of Hammer Mills in the World

CHAIN



BELT IDLERS

Jeffrey equipment stocked for shipment



BUCKETS

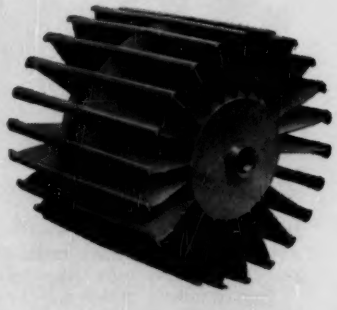
SPROCKETS

From factory or distributor stocks you can get fast service on a host of Jeffrey products... for elevating and conveying machinery and many industrial applications.

When replacing parts or modernizing machinery, it's wise to use genuine Jeffrey equipment. Highest manufacturing standards, based on years of experience, assure dependable performance. For service, call your Jeffrey distributor or write The Jeffrey Manufacturing Company, 909 North Fourth Street, Columbus 16, Ohio.

PULLEYS

PILLOW BLOCKS



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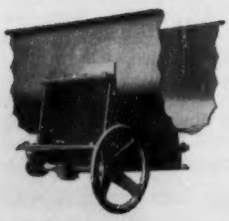
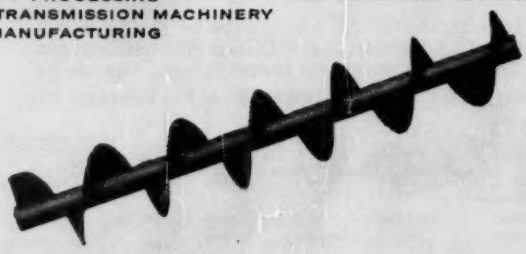
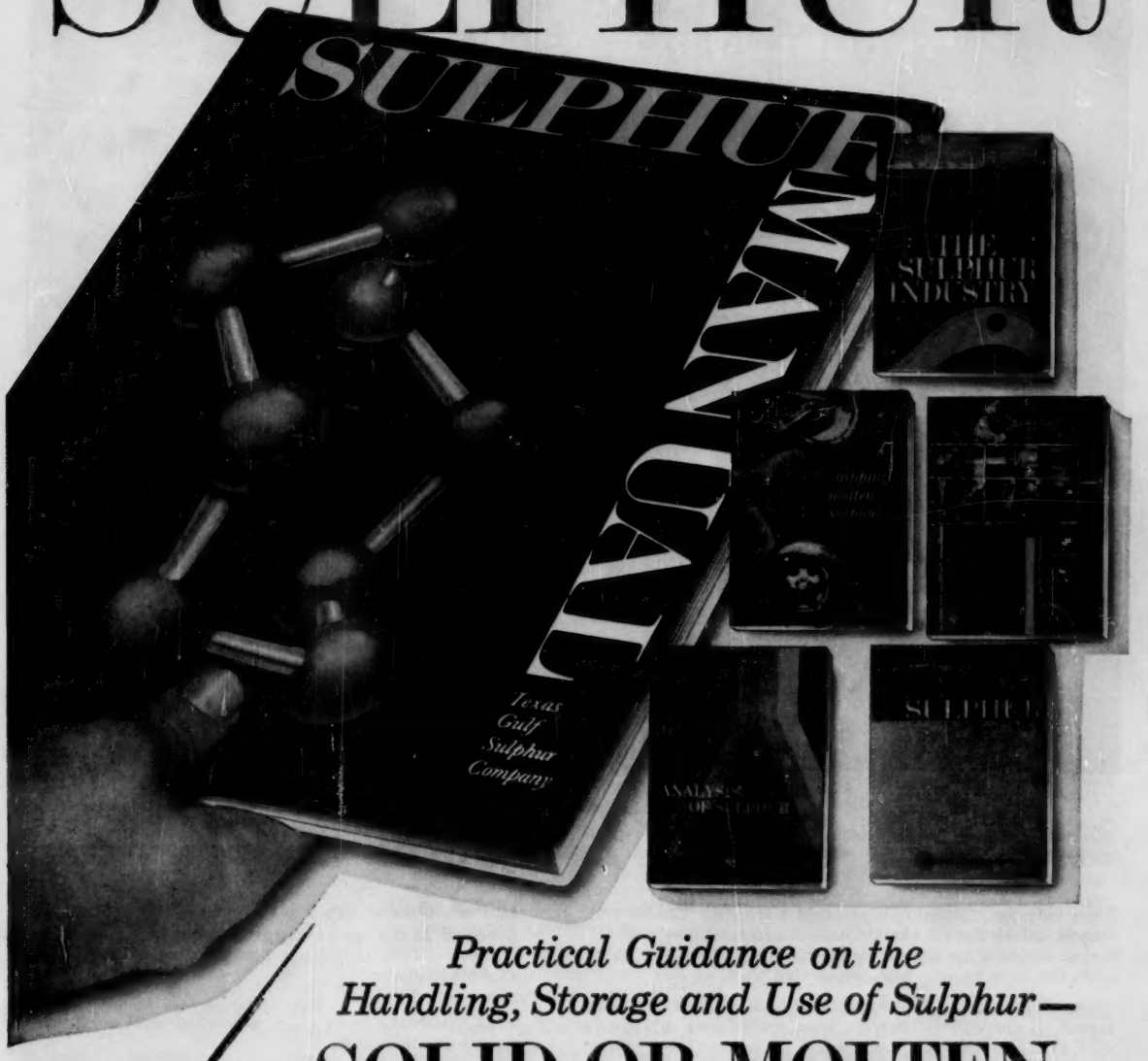


DISCHARGE VALVES

SPIRAL CONVEYORS



SULPHUR



Practical Guidance on the Handling, Storage and Use of Sulphur—

SOLID OR MOLTEN

I — The Sulphur Industry
II — Shipping Molten Sulphur
III — Handling and Storage of Molten Sulphur
IV — Analysis of Sulphur
Appendix — Physico-Chemical Properties of Sulphur

Old hands, accustomed for years to handling Solid Sulphur, will need little advice, if any...unless Molten Sulphur is to be in the picture for the first time. In this case, our experience with and knowledge of Molten Sulphur may be helpful.

But new plants entering the Sulphur-consuming picture for the first time should find our service of considerable help regardless of the kind of Sulphur used. One facet of this service consists of a well-documented and well-illustrated 5 section Manual covering all phases of the handling, storage and use of Sulphur, both solid and molten, plus useful information on sampling, analyzing, and broad properties of Sulphur.

As a preliminary to any service in person you may require—and which we shall be glad to provide—would you like to have a copy of this Manual? Please write us on your company's letterhead and address your request to our Sales Department.

TEXAS GULF SULPHUR COMPANY

75 East 45th St., New York 17, N. Y. / 811 Rusk Ave., Houston 2, Texas

Sulphur Producing Units: Newgulf, Texas • Spindletop, Texas • Moss Bluff, Texas • Fannett, Texas • Worland, Wyoming • Okotoks, Alberta, Canada

"Buffalo" Air Cooled Condensers Handling Propane Gas on Refrigerated Liquid Propane Storage Spheres. Photo—Courtesy of Rust Engineering Co.

WITH NEW "BUFFALO" AIR COOLED CONDENSERS

Some time ago, "Buffalo" began field testing Air Cooled condensers and Air Cooled Liquid Coolers of completely new design. But we withheld the advertising of this unique product until we could talk in terms of a **field-proven** unit. Now, we can.

"Buffalo" Air Cooled Condensers have been installed on a wide variety of applications. Reports from actual users now prove their highly efficient and economical operation. They provide complete freedom from operating difficulties. Service requirements are reduced to an absolute minimum.

These field reports prove beyond all doubt that the new "Buffalo" units have eliminated the difficulties common to most air cooled condensers.

Only "Buffalo" Air Cooled Condensers Bring You All These Advantages:

VERTICAL DISCHARGE—is not affected by wind velocity—holds compressor on line.

EASY-TO-INSTALL—shipped as factory-assembled packages. Lifting eyebolts simplify rigging.

LOW SILHOUETTE—the No. 1000 unit is only 76" high.

OPPOSED BLADE BY-PASS DAMPER CONTROL AVAILABLE—provides close modulating control not possible with parallel-blade dampers—or with "flooded coil control". Saves expensive refrigerant.

UNIT CASINGS—heavy-gauge galvanized steel construction insures durability, long life.

AMPLE CAPACITIES—Standard sizes from 7½ to 100 tons based on 120° condensing temp. 40° suction, 100° ambient. Larger sizes for special refrigerant, liquid or gas cooling applications available as factory-assembled packages.

Applications of "Buffalo" Air Cooled Condensers include air conditioning and steam condensing . . . also jacket water cooling of diesels, package compressors, gas turbines, electronic tubes, power transformers, process liquids, heat pumps.

For the utmost in reliable performance, new "Buffalo" Air Cooled Condensers are your best choice. Call your nearby "Buffalo" engineering representative for complete facts. Or write us direct.

"Buffalo"

BUFFALO FORGE COMPANY Buffalo, N. Y.

Buffalo Pumps Division, Buffalo, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING • AIR CLEANING • AIR TEMPERING • INDUCED DRAFT • EXHAUSTING • FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING

Maintenance and Steam Traps

. . . there's a relationship that goes far beyond trap maintenance alone

Good traps and good trapping have a greater effect on your maintenance costs than does trap maintenance itself. By that we mean that the right traps, properly selected and installed, and with the benefits of a preventive maintenance program, will save far more maintenance dollars than they will cost.

Under the pressure of spiralling maintenance costs, this thought becomes mighty important. Let's take a look at what it involves:

Proper Selection of Steam Traps

1. Be sure it's the right type of trap.

2. Be sure it's sized right and is for the correct operating pressure.

3. Be sure it's first rate in design and construction.

Proper Installation of Steam Traps

1. Install them so they are accessible for inspection and maintenance.

2. Install a test valve.

3. Use a union or unions.

4. Use a shutoff valve or valves.

5. Use a strainer ahead of the trap if dirt conditions are bad.

6. Use a by-pass only where continuity of service is imperative.

7. Standardize inlet and outlet connections.

Preventive Maintenance Program

1. Test trap regularly for proper operation. (Trap size, operating pressure and importance determine frequency.)

2. Inspect internal mechanism at least once a year.

You Get Indirect Benefits As Well

The direct benefits of the plan outlined are pretty obvious — good traps, properly selected, require less maintenance . . . testing and inspection prevents troubles that lead to maintenance.

However, this plan provides indirect benefits which reduce maintenance in other parts of the plant as well:

Good traps save steam and reduce the load (and consequently maintenance) on fuel handling and burning equipment and on ash handling equipment.

Good traps protect the system by eliminating water hammer and preventing the damage it can do.

Good traps discharge carbon dioxide before it can go into solution to form corrosive carbonic acid — less corrosion, less maintenance.

Good traps increase production to reduce the length of time equipment must operate or reduce the amount of equipment needed . . . either way maintenance is reduced.

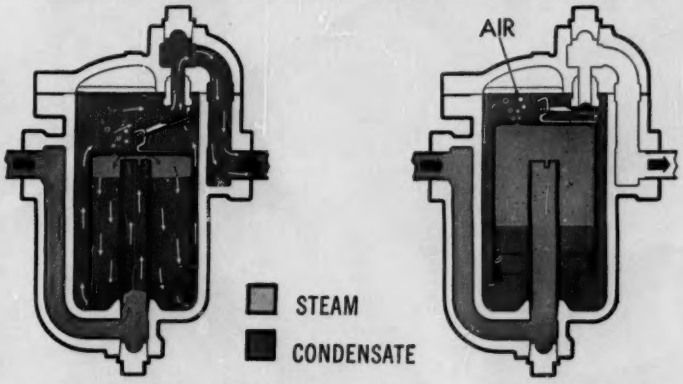
How to Go About It (The Sales Pitch)

We admit we're prejudiced, but we don't think there is any better way to select steam traps than with the help of the 44 page Armstrong Steam Trap Book. Here in a single source is specific data on the selection and sizing of traps, how to install them for best results, and how to maintain them most economically.

The Steam Trap Book will also give you full information on the design and construction of Armstrong Inverted Bucket Steam Traps that offer these important maintenance-reducing advantages:

1. Armstrong Traps are dependable.

HERE'S THE STEAM TRAP DESIGN THAT CAN REDUCE YOUR MAINTENANCE PROBLEMS



Trap open. Condensate entering trap has caused bucket to lose buoyancy. Weight of bucket times leverage pulls valve open. Air is discharged along with condensate.

Trap closed. Steam has floated inverted bucket; valve is held tightly closed by system pressure. Air entering trap passes through bucket vent and accumulates at top of trap.

2. Armstrong Traps require no adjustments — go from full load to zero load automatically.

3. Armstrong Traps are self-scrubbing—ordinary dirt conditions can't hurt them.

4. Armstrong Traps have long-life parts — valve and seat are heat treated chrome steel — lever assembly and bucket are stainless steel.

5. Armstrong Traps have water sealed valves to minimize wire drawing and erosion.

Ask for your copy of the Steam Trap Book—there is no obligation. Then test Armstrong Trapping. If you are not completely satisfied with the results, you can return the traps for a full refund of the purchase price. You can't lose much that way. Call your local Armstrong Representative or Distributor, or write

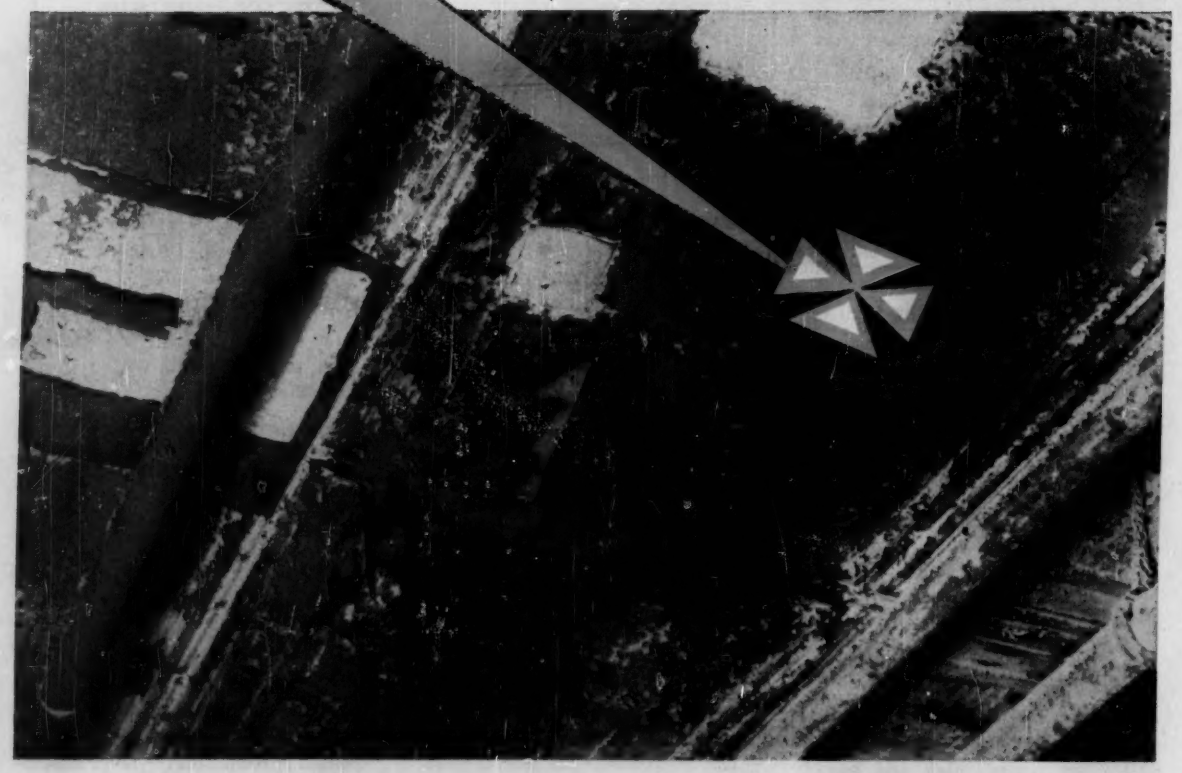
Armstrong Machine Works
8585 Maple Street
Three Rivers, Michigan

ARMSTRONG STEAM TRAPS

"SEE OUR CATALOG IN CHEMICAL ENGINEERING CATALOG"

"X" MARKS THE SPOT

where a $1.05 saving went through the roof!



On a 250 gallon paint order, the Plant Maintenance Department figured to save $1.05 per gallon by using a paint that was cheaper, and "just as good" as Tygon. The cheaper paint *appeared* to be doing a good job — then the roof fell in!

These people learned the hard way what most corrosion engineers already know: the cheapest paint rarely gives the most economical protection. Where proven corrosion resistance is concerned, it's virtually impossible to find a paint that offers lower *cost per year per square foot of protection* than Tygon Paint.

Tygon Protective Coating Systems are designed for practical application of specialized protection against a wide range of specific corrosives and exposure conditions. The broad Tygon line includes vinyl-based coatings, as well as formulations based on epoxy resins. Depending upon the specific use for which each coating is designed, Tygon Paints provide more effective, longer-lasting protection against such corrosives as acids, alkalies, oils, water, alcohols and many solvents. Tygon is available for simplified, economical application by brush or cold spray — and in the Tygon "ATD" Series — by hot spray methods.

Properly applied and used under the specific conditions for which they are recommended, Tygon Coatings will outlast and out-perform practically any other paint available today.

Write for this free Tygon Data Book. It gives complete application details plus helpful information on resistance of Tygon to over 150 corrosives.

PLASTICS & SYNTHETICS DIVISION

U. S. STONEWARE

AKRON 9, OHIO

101-G

Tygon is a registered Trade Mark of the U. S. Stoneware Co.

DEVELOPMENTS . . .

JANUARY 11, 1960,

Chementator

T. PETER FORBATH

Ampex is eyeing polypropylene as replacement for polyester (Mylar) magnetic-tape backing. Material is cheaper, is said to have good dimensional stability. Too, company is working with polyurethane film for extreme-temperature jobs.

Off-the-road use of urethane tires may come this year, ventures Dayton Rubber, on-the-road military and civilian use soon thereafter. Company believes such tires will have life of 100,000 miles. Firm also is experimenting with "plastic-foam-filled" tires.

Monsanto, Heyden Newport and Kellogg have reached secret, out-of-court settlement of their legal dispute over contract for design, construction of $6.5-million methanol plant (Chementator, May 4, p. 39).

Industry eyes atom-fuel reprocessing

Private industry is beginning to heed Atomic Energy Commission's repeated plea to get into the business of reprocessing spent nuclear fuels (*Chementator,* Nov. 30, p. 19). Five electric utilities, each with a privately financed nuclear reactor in the works, have teamed with Davison Chemical in a 6-mo., $250,000 study to determine the economic and technical feasibility of a privately owned nuclear-fuel reprocessing plant.

Called the Industrial Reprocessing Group, the six-firm team has elected AEC's Purex process as the most promising flowsheet, now seeks to establish investment required by and return on investment possible from a plant designed to reprocess all the various fuels that would be supplied by the five utilities' reactors. Davison is directing the study. And if it turns up the results AEC hopes it will and believes it should, Davison will build, own and operate the plant.

Key to study's outcome depends largely on what sort of return on investment IRG will consider adequate. If, as has been the inclination of most private firms eyeing the reprocessing field, it wants much more than a 10% return, there's little chance Davison will be able to reprocess the utilities' fuels at costs competitive with the AEC; thus, there'd be little likelihood it would go ahead with a private plant. But if Davison would accept a 6-8% return, prospects for the first private reprocessing plant would be bright.

Technical aspects of study pose very few problems, a Davison spokesman notes. Purex process has been proved out on large scale at AEC's reprocessing facilities (see p. 113 this issue).

Engineer shortage is here again

Recent recession in engineering employment is definitely a thing of the past. In spite of a great increase in supply—38,162 B. S. engineering graduates—employers

if you are dispersing products like these...

CHEMICALS and kindred products including organic and inorganic chemicals, drugs, medicines, pharmaceuticals, cosmetics, cleaning and polishing preparations, waxes, fertilizers and insecticides, etc.

PAINTS, VARNISHES, LACQUERS, ENAMELS and similar coatings.

PETROLEUM products including greases, oils, roofing materials, fuels, etc.

STONE, CLAY and **GLASS** Products.

FOOD and kindred products including meat, dairy, fruit, vegetable, fish, bakery, confectionery, cooking fats, extracts, food preparations, etc.

TOBACCO end-products.

TEXTILE dyes, finishes, coatings.

LUMBER & WOOD coatings.

PAPER coatings and glazes.

PRINTING inks.

LEATHER dyes, special polishes, etc.

CERAMIC slips, body materials and glazes.

METAL core washes, mold coatings and special protective coatings.

MISCELLANEOUS including pencils, crayons, carbon paper coatings, cork products, matches, etc.

RESEARCH LABORATORIES and similar services.

new COWLES super series DISSOLVERS

with the exclusive new... MPD* *(Maximum Power Delivery) transmission system*

This model:
Height in lowered position—83½"
Height in raised position—125½"

will produce many times as much as ordinary mixers...better, in less space, at less cost!

The new Cowles Super Series Dissolvers are high speed, high shear, impeller-type units. They easily handle viscosities in excess of 50,000 centipoises and are the only full proven units for big plant production as well as small.

Now, in addition to "the teeth that make the BIG difference," the new "MPD" unit, including full instrumentation, offers important advantages not available in any other mixer.

1. **It is capable of delivering over 90% motor horsepower to the impeller even at lowest speeds.**
2. **Speeds may be easily changed during processing operations.**
3. **Use of proper size motor assures important savings in first cost and power consumption.**

Let us prove it in your plant at our risk!
Write today for more complete information.

MOREHOUSE COWLES

MOREHOUSE · COWLES, INC.
1150 San Fernando Road, Los Angeles 65, California
Representatives in Principal Cities
Convenient lease and time-payment plans

* Trademark of Cowles Dissolver Company. 6937

weren't able to satisfy their recruitment goals in 1959, according to Engineering Manpower Commission.

Moreover, things will get worse for employers and better for engineers in the years immediately ahead. Demand is predicted to be up again in 1960 and will accelerate until at least 1966, barring economic disaster and assuming stability in government spending.

Meanwhile, enrollments in engineering colleges have declined for two successive years. Entering freshmen in the fall of 1958 numbered 11% fewer than their 1957 counterparts (*Chem. Eng.*, Aug. 10, p. 148). Final 1959 figures on enrollment show another drop; this time 3%.

One bright hope offered recruiters by the EMC report is the decline in engineering turnover. Older engineers are staying on their jobs. Turnover averaged 11% in 1957; 9.5% in 1958; and is expected to drop to 8.6% when the books are closed on 1959 figures.

As you might expect, imbalance of demand vs. supply propelled salary structures upward. Median monthly salary paid by industry to 1959 B. S. graduates was $510/month. Masters of Engineering got $600 and Ph. D.'s received $825/month. However, chemical employers paid below the median: $500 to B. S. graduates; $563 to M. S.'s; and $745/month to Ph. D.'s.

Phosphate-fertilizer boom brewing

There's a boom brewing in phosphate fertilizers that seems likely to send U.S. capacity to an unprecedented high and, in some observers' views, bring on a bad case of overcapacity before this new year is out.

Three leading builders of phosphoric acid and phosphate fertilizer plants—Dorr-Oliver, Chemico and Fluor—tell *CE* that they're bidding on, designing or building new capacity at a pace one company official describes as "breathless." And a *CE* check of phosphate producers uncovers a strikingly long list of plans for increased output to verify this claim.

Among them: General Chemical "somewhere in the Midwest"; American Cyanamid at Brewster, Fla.; Smith Douglass at Streator, Ill., and Texas City, Tex.; International Minerals & Chemicals at yet-to-be-chosen site; Davison Chemical at Joplin, Mo., and Bartow, Fla.; Virginia-Carolina at Nichols, Fla.; Monsanto at Columbia, Tenn., and Soda Springs, Idaho; Bunker Hill at Kellogg, Idaho; Swift, Farmer Fertilizer and U.S. Phosphoric at undisclosed locations.

Primary spur behind this boom: Government's reduction of acreage allotments under its farm program. Explains an industry observer, farmers are seeking to get the most crop production per farmable acre. And this means a mounting demand for high-analysis, phosphate-type fertilizers. More than one phosphate producer, *CE* learns, has already sold out its entire expected 1960 production.

But there's a gnawing fear among some firms that the quickening race to meet demand will result in a bad case of overcapacity. For one, U.S. Industrial Chemicals strongly cautions its colleagues to add only enough output capability to satisfy "normal" 5%/yr. market growth.

Freeze desalting will go commercial

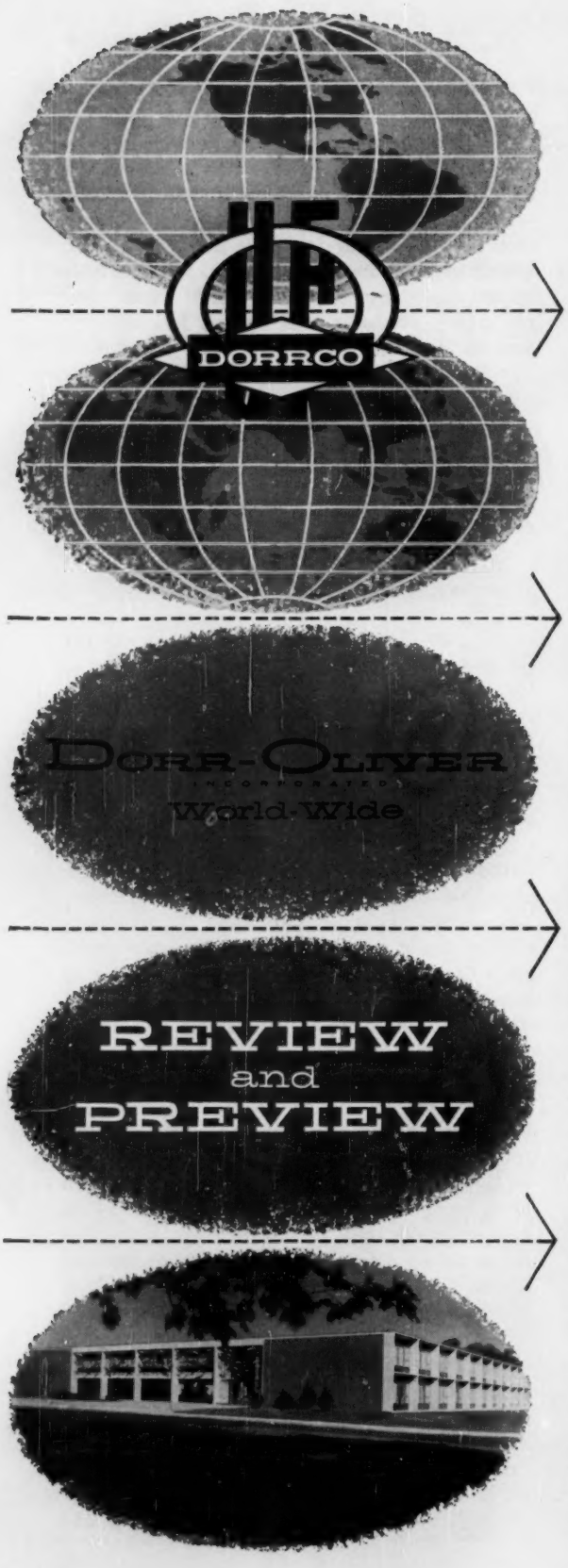
Water desalting via freezing is headed for commercialization. Fairbanks, Morse & Co. has signed with Israel to build full-scale salt water-conversion plants that harness the freezing process invented and brought to the advanced pilot plant stage by Alexander Zarchin under sponsorship of Israel's Ministry of Development.

First project: Two plants with combined output of 500,000 gal./day to be built this year at a cost of $1 million in the Negev Desert. Thereafter, F-M expects the increasingly thirsty world to beat a path to its door. Reason: Zarchin's process is claimed to be able to produce fresh water from salt at the amazingly low cost of 40¢/1,000 gal.

In a day when $1/1,000 gal. is regarded as an optimistic figure for "artificial" water, F-M's figure is a powerful lure. *CE* learns that California's Gov. "Pat" Brown has already called for talks with the Chicago firm on the prospects of building the third Zarchin plant in the southern part of his state. F-M has revealed that it has definite plans for constructing a facility in the U.S. Southwest. States the company, "Our goal is to install 1-billion-gal./day capacity by the end of 1965."

Precise details of Zarchin's route are being kept under tight wraps. And F-M is quick to point out that, while commercial plants will follow basic scheme outlined in Zarchin's various patents, they will incorporate undisclosed "revolutionary" engineering

(Continued on p. 40)



1959 has been a paradoxical year. With the public press reporting good business for the country as a whole, it has taken a discerning student to discover that the part of the economy relating to capital goods has only bettered to a modest degree. This fact, plus the low carry-over of orders from 1958, caused us to have an unhappy year financially.

However, with the modest but positive increase in business in the U.S.A. and the substantial increase in orders for most of our overseas areas, we look forward with confidence to 1960. Improvement of efficiencies in all internal departments has also been positive and is continuing both as to costs and the time it takes to do things. This naturally will be beneficial to our customers.

SANITATION—Once again this segment of our operations has played a dominant role in our worldwide business during the past year. Orders were placed with us and our subsidiaries to serve larger centers of population such as Trenton, New Jersey; New York City; Bagdad, Iraq; Chicago, Illinois; and Elizabethville in the Belgian Congo, as well as for smaller municipalities from Pierrefond, Ontario to Albertville, Alabama and from the Villa Carmen housing development in Puerto Rico to Harlingen, Texas. Two large U.S. corporations also will install D-O equipment in treatment plants constructed for a research laboratory in New York State and a West Virginia townsite.

Further proof of widespread acceptance of our newer developments is installation of a SpiroVortex system at Checotah, Oklahoma and of CompleTreator units at industrial plants, recreation centers, housing developments and military sites in the United States. Abroad, our Dutch subsidiary will install one of these units in a concrete rather than steel tank, and the first CompleTreator unit has been purchased in the Philippines. The latter, for a large refinery, represents the first export order for our manufacturing representative in Malaya.

New applications of proven equipment include use of the ODS pump for handling conditioning lime for sewage sludge filtration and fabrication of a plastic sludge filter. Also, development work continues on additional applications of our industrial equipment in the sanitary field.

SUGAR—Orders from new and expanding cane sugar factories in India for RapiDorr Clarifiers and Oliver-Campbell Filters contributed significantly to the business of our subsidiary in that country. And in other locations around the world—Mexico, British Honduras, Egypt, Mozambique and Swaziland, for example—these two units continued to be accepted as standard in the industry. In beet sugar, a British producer purchased First Carbonation Thickeners and Vacuum Filters for two new mills; and two Italian mills will use a total of four Vacuum Filters.

PETROLEUM—A variation of the initial application of the DorrClone Desanding System in fresh water treatment is the desanding of salt water used to recharge wells for secondary oil recovery at a West Coast location. Outside the U.S. our Japanese representative is fabricating filters for use in a catalytic cracking process and our British company will supply oil-water separators for both British and Brazilian refineries. Also of interest is equipment for a pilot plant to recover oil from tar sands.

PROJECT ENGINEERING—This phase of our operations was also particularly active in 1959 as design of phosphoric acid plants to be located in Idaho, Great Britain and Ireland and a phosphoric acid and triple superphosphate installation for Brazil was commenced. Also in the fertilizer field was a contract for process modification of a large British plant.

Late in the year, work was started on design of a large limestone crushing plant for which D-O will also purchase equipment and other materials. Our French subsidiary and domestic company working jointly virtually completed design of a large Yugoslavian copper concentrator. Two smaller but nonetheless significant projects—both including laboratory testing and feasibility studies—involved production of a limestone substitute to be used for self-fluxing sinter in blast furnace operation and the recovery of nickel from waste pickle liquors.

WATER—Conventional pre-treatment equipment will be utilized at D-O supplied water plants for a new steel mill in India, a military camp in Iraq and the municipalities of Wilmington, Delaware; New Castle, Pennsylvania; Saida in Lebanon; and Maracaibo and Naiquata, Venezuela. Next year new PeriFilter systems will go into operation at New Oxford and South Pittsburgh, Pennsylvania and in 1959 a large system with two Hydro-Treator mechanisms went on line treating Midland, Michigan's water supply.

FLUOSOLIDS SYSTEMS—One of the new applications of the FluoSolids System this year has been preheating coarse shale in a special three-compartment reactor to produce light-weight aggregate. A second is drying iron ore before magnetic separation and concentration. Currently, the iron ore industry appears to have other drying applications ideally suited to fluidization. FluoSolids roasters are also under construction for a Canadian smelter where only partial sulfur removal is required.

Projects involving already proven applications have included in 1959 a pyrite roaster for a sulfuric acid plant on Formosa, three systems marketed by our Italian subsidiary for roasting pyrite to produce sulfur dioxide for pulp mill bisulfite cooking liquor and for a large zinc roasting installation in Yugoslavia, a large coal dryer for a Western producer, a copper-cobalt roaster in the Belgian Congo and detergent dryers in the United States.

METALLURGICAL—As in past years our work in this area has involved virtually all of the metallic minerals from gold to iron ore. The latter field has been among the most active with purchase of Sizers and Filters for Canadian washing plants, DorrClone classifiers for desliming prior to flotation and Thickeners, Filters and Pumps for recovery of blast furnace flue dust.

PULP AND PAPER—A new tool for this industry is a novel pressure washing filter. Installation of the first U.S. manufactured unit is being made in a Southeastern pulp mill. Ideally suited to brownstock washing, the unit has a number of advantages from both the operating and installation standpoints.

Recausticizing systems including process flowsheet innovations, such as precoat operation of the Lime Mud Filter and application of a two-compartment White Liquor Clarifier with special feedwell, were purchased for new or expanding mills in Canada, India, the United States, Portugal, Japan, Yugoslavia, Scandinavia and the Philippines.

Around the world the American Saveall continued to be recognized as the major means of recovering paper machine fibers from white water and in the U.S. the largest bleach tower designed to date will soon go into operation. An unusual and interesting application of the Merco Centrifuge is recovery of by-product material used as a drill mud dispersant at a West Coast mill.

CHEMICAL—During the year applications of the Plastic Filter, first introduced in mid-'58, were broadened to include a variety of fine chemical and pharmaceutical separations and washing of acid leach liquors from metallurgical pulps. Also in the realm of new applications is dewatering of various plastics using the Mercone Screening Centrifuge.

As usual, our standard line of equipment played a major role in a great number of Italian chemical plant expansions and in large new or expanded facilities in France, Germany, Spain, Mexico and here at home.

FOOD PRODUCTS—Successful application in 1958 of the Mercone-Precoat Filter combination for apple juice processing has resulted in orders from two West Coast packers for similar stations.

In starch, several domestic and overseas producers will employ D-O centrifugals of virtually every design for current modernization and process modification projects. Our Dutch subsidiary has put into operation three corn and potato starch washing and processing plants in Germany and Finland.

NON-METALLICS—A new clay and sand plant in Idaho will utilize considerable D-O sedimentation, filtration and centrifugal classification equipment and a Pennsylvania limestone producer has purchased Classifiers and a large Thickener for installation in an earthen basin. Also in the clay industry, the longest Oliver drum filters ever fabricated—24 feet in length—will be shipped early next year to a Southern producer.

We have noticed with much concern the apparent growing tendency of many users of services and equipment to buy almost exclusively on price rather than on demonstrated product quality and the essential engineering services made available to them during planning and after installation. This is not a new subject—and one on which there has been much forceful editorial comment in the technical press.

This practice confronts the supplier with the practical short range choice of sacrificing product quality and needed engineering, losing the business, or taking it at a loss. For our own part, we do not propose to fall into this trap which, economic considerations aside, can only result in arresting technological advance and which could have a profound effect on the leadership of the free world in things technical.

J. D. HITCH, JR.
Chairman of the Board

December 1, 1959

RapiDorr, SpiroVortex, CompleTreator, DorrClone, Hydro-Treator, FluoSolids, Merco, Mercone, T.M. Reg. U.S. Pat. Off.

innovations that hold the key to the process' enviable economics. Patents describe vaporizing a compressed or "liquefied" gas such as CO_2, air, propane or isobutane through salt water held in a low-pressure chamber. Heat of vaporization is supplied by salt water which partially freezes as a result to produce salt-free ice.

Pulping route whips stream pollution

Engineers, long used to charting step-by-step progress in sulfite pulpers' efforts to whip stream pollution, welcomed a *fait accompli* last month. At Hoquiam, Wash., Washington State Pollution Control Commission granted Rayonier a *permanent* permit to continue acid-sulfite pulping in its Grays Harbor mill.

Behind this action lies Rayonier's decision to lay out $7.5 million to provide, by 1961, a completely effective guard against stream pollution at its 500-ton/day mill. Company will install a new sodium-base pulping and recovery system that promises initially to recover 85% of pulping chemicals, and even more after shakedown.

While other chemical recovery systems also may ultimately master sulfite-waste pollution, only the magnesium-base system has achieved full commercial status in the U.S. prior to Rayonier's development (*Chem. Eng.*, Sept. 8, 1958, p. 60). Rayonier attributes its success to chemical and heat recovery features which lower cost at the same time that they abate pollution. Company has solved the riddle of how to recover economically an SO_2-rich gas and pure sodium carbonate crystals which can be recombined as a fresh pulping solution of sodium bisulfite and sulfurous acid.

Waste liquor is stripped free of SO_2 with steam. Addition of recovered sodium carbonate neutralizes free lignosulfonic acids and SO_2, provides enough sodium to reduce sulfur losses out stack and supplies excess sodium carbonate needed to lower melting point of furnace smelt to free-flowing range. After filtration to remove calcium and other insolubles, liquor is concentrated to 65% solids and burned under reducing conditions to produce flue gas essentially free of SO_2 or H_2S.

Sodium sulfide-sodium carbonate smelt is dissolved preferentially, leaving sodium carbonate crystals. These neutralize incoming waste, serve as makeup for fresh pulping liquor. Pressure carbonation and vacuum stripping of concentrated sulfide-carbonate solution produces H_2S which is catalytically converted to molten sulfur, then burned to SO_2 for makeup of sulfite liquor.

Aluminum alkyls: Race is on

Though no big markets yet exist, production of aluminum alkyls—vital ingredients of Ziegler catalysts—has become a booming business virtually over night. Texas Alkyls (jointly owned by Stauffer and Hercules) started up a plant in Houston, Tex., officially rated at 2 million lb./yr. but which, according to the company, "could turn out a lot more." And Ethyl Corp. has put into operation an installation at Orangeburg, S. C., identified as having a "multimillion-lb./yr. capacity."

That this capacity is far greater than the market needs right now, no one, least of all the producers themselves, will deny. But Ethyl and Texas Alkyls are confident that this demand picture will brighten markedly in the next few years. Reason: Most low-pressure polyethylene and polypropylene processes use Ziegler-type catalysts. So do the new polybutadiene, polyisoprene and Ziegler straight chain-alcohol processes.

Furthermore, another big future for aluminum alkyls may lie in non-catalytic applications, for example, as pyrophoric fuels for ram-jet engines, for olefin displacement.

But a threat of legal action clouds this brightening view. Ethyl has filed a complaint in U.S. District Court in Delaware charging that Hercules and Texas Alkyls have been claiming exclusive sales rights on alkyls manufactured under Ziegler patents, and have threatened Ethyl and Ethyl's customers with infringement suits. Ethyl asserts that it's a Ziegler licensee too, and both licenses are nonexclusive.

Texas Alkyls counters that this is the sole claim it has been making: Under its Ziegler license, it has exclusive rights to sell aluminum trialkyls in the U.S. made by the Ziegler process.

New heat-transfer agents make debut

A new series of heat-transfer agents—the tetra aryl silicates—will chalk up their first chemical processing applications in the U.S. next month. Phillips Chemical will bring on stream a unit for heating and cooling process kettles at its Borger, Tex., plant using these

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SODIUM BIFLUORIDE
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SODIUM BISULFITE, ANHYDROUS
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SODIUM FLUOBORATE
SODIUM FLUORIDE
SODIUM METASILICATE,
CRYSTAL AND ANHYDROUS
SODIUM PHOSPHATE, DIBASIC
SODIUM SILICATE
SODIUM SILICOFLUORIDE
SODIUM SULFATE
SODIUM SULFITE, ANHYDROUS
SODIUM TRIPOLY PHOSPHATE
SODIUM THIOSULFATE (HYPO)
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materials. Earlier, General Electric had named the silicates for heating oil at its jet-engine-test facilities in Cincinnati.

Products were brought to this country and are now marketed exclusively in liquid heat-transfer systems by American Hydrotherm Corp. (New York). In England and Europe, where they've been available for about a decade, numerous commercial applications exist in jacketed reaction vessels, distillation columns, etc.

Tetra aryl silicates, claims American Hydrotherm, maintain operating temperatures between —50 and 750 F., are used wholly in the liquid phase (pour point, 5 F.) and don't require pressure vessels. These features combine with attractively low cost—$3 to $16/gal. Dowtherm or steam require pressure vessels; chlorinated biphenyls and polyphenyls such as Monsanto's Arochlors operate only up to 600 F. and fluorochemicals are generally more expensive than the new materials.

Tomorrow's Technology

Today's embryonic developments which have special significance for chemical engineers

Driveable rockets for man in space

Major advance to the day of manned space flight comes in the development of "driveable" variable-thrust rocket engines.

• Aerojet-General last month revealed that it has come up with a liquid-fueled rocket engine whose thrust can be throttled up and down between 50,000 and 150,000 lb., shut off entirely and started up again, all while in flight.

• Thiokol's Reaction Motors Div. reports it's readying a new liquid-fueled power plant for North American's X-15 hypersonic rocket plane whose thrust can be varied from 25,000 to 50,000 lb., as well as be shut off and restarted after initial firing. Unit will replace X-15's presently used two four-chambered engines, also developed by RMD, that are fired in various combinations to create the effect of varying thrust.

Aerojet's engine burns a hydrazine-based fuel and a nitric-acid-derived oxidizer; RMD's motor uses ammonia and liquid oxygen. But, claim both companies, engines are readily adaptable to any liquid propellant system, including big-punch combinations such as liquid hydrogen and liquid oxygen.

Aerojet hasn't revealed details on how it gets the variable-thrust feature other than to say that a throttling valve "alters pattern of fuel and oxidizer feed" to combustion chamber. This valve can be controlled by radio signals or by "flight personnel." RMD points out that chief obstacle that had to be hurdled in designing variable-thrust engine was possibility of even small amounts of unfired propellant accumulating in combustion chamber upon throttling which would blow engine to pieces upon sudden deflagration.

Processing in chemonuclear reactor

Chemonuclear reactors—in which chemicals are synthesized by direct exposure to high-energy fragments of nuclear fission—may prove the way to the long-sought but elusive goal of processing via atomic energy.

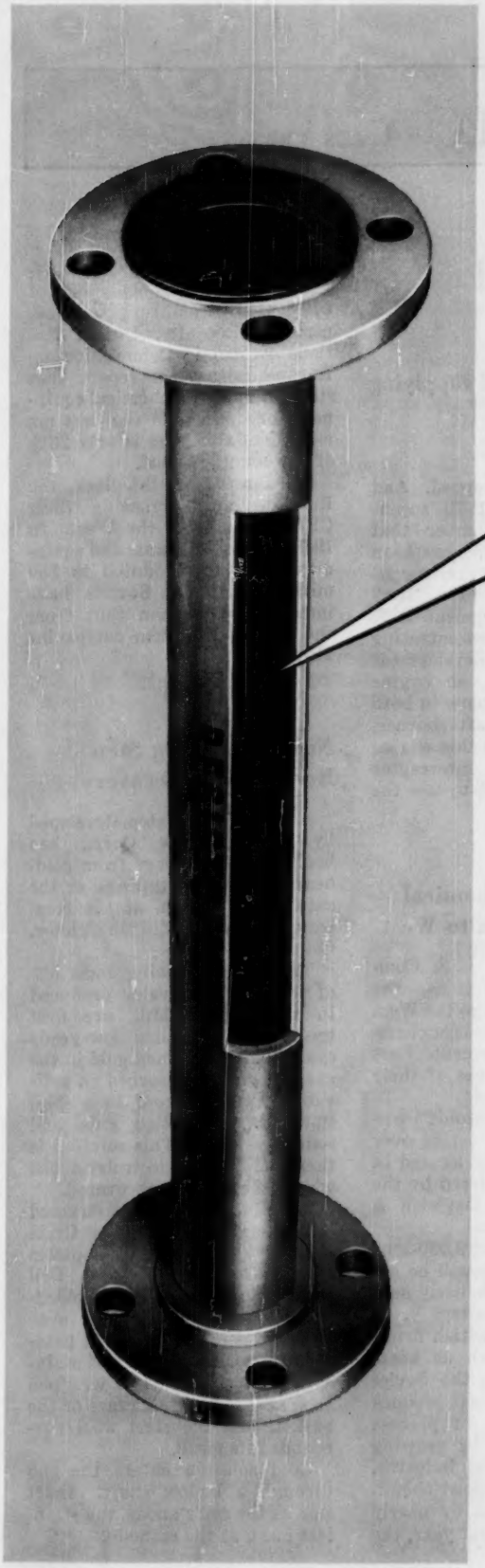
Strong backer of this view is Hercules. Last month company revealed that it has been researching the prospects of running hitherto impossible chemical reactions in a new reactor type, the Circulating-Dust Nuclear Reactor (CIDUR). Its efforts, which have included small-scale tests at Battelle and Argonne, indicate that syntheses such as dimerization of methanol to ethylene glycol and nitrogen fixation are "feasible."

But, acknowledges Hercules, there's a long, costly road ahead before chemonuclear reactors will become commercial. Company's goal: $20-$30-million, 100-megawatt (thermal) CIDUR by 1973 to run nitrogen fixation reaction on a 100-million-lb./yr. scale.

Key attraction of chemonuclear reactor over "machine" radiation for chemical processing stems from the fact that the former provides a heftier "nuclear punch", so can initiate and sustain chemical reactions once thought impossible. Specific attraction of CIDUR over other reactor types is that it employs energy of fragments most efficiently.

Hercules isn't only outfit interested in chemonuclear processing. Brookhaven Lab has centered attention on glass-fiber-uranium-fueled reactor for nitrogen fixation. Rensselaer Polytechnic researchers also are looking at fiber fuels. And Atomics International is running test reactions in an Organic Moderated Nuclear Reactor.

For more on DEVELOPMENTS.....44



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3. Fluoroflex-T liner is formed over the full gasket face of the flange, so that no extra gaskets are needed. The smoothly-faced Teflon flange surfaces fit together, to form a perfect seal *without leakage!* The gasket faces adjust to each other with complete closure to liquids, even up to 150 psi pressure!

4. Fluoroflex-T lined pipe has inherent thermal expansion equilibrium between the liner and the steel, the result of years of research and design by Resistoflex, pioneers in fluorocarbon developments. This Resistoflex feature is essential for optimum service life at high temperatures.

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Boron-Fuel Status Changed

Callery, instead of Olin Mathieson, wins job of supplying boranes for rocket-fuel studies.

Defense Dept.'s decision on the fate of the three boron fuel plants (*Chementator*, Oct. 19, 1959, p. 95) has been modified. After a flurry of new contract bidding called for last month by the Air Force, the $38-million, 5-ton/day plant at Muskogee, Okla., operated by Callery Chemical, has won the job of supplying AF with 1,000 lb./day of borane fuels for research studies on use of these high-energy propellants in rocket engines.

Earlier, Pentagon had ruled that the 0.8-ton/day plant at Lewiston,. N. Y., run by Olin Mathieson, would be the source of the research quantities of pentaborane and decaborane needed. Now that plant is slated to go out of action entirely.

Reason for change in plans: Pentagon studies indicate that the Callery facility can turn out the small amounts of boranes required more efficiently and economically than the OM unit. Callery installation will undergo a $500,000 revamp to handle its new assignment, should be in operation within four months. The third of the boron-fuel plants, the $45-million, 5-ton/day facility at Model City, N. Y., also run by OM, will be shut down and dismantled as originally planned. Much of the equipment from that installation is now expected to be used in the revamp of the Callery plant.

Collapse of the boron-fuel program stems, chiefly, from AF's decision to shelve its projects for "chemically" fueled, air-breathing aircraft. The J-93-5 jet engine, designed to burn hydrocarbons in the turbojet portion and boranes in the afterburner, has been dropped. And production of the B-70 supersonic, long-range bomber that was to use this engine has been canceled. AF now is limiting itself to manufacture of a "few" research and development B-70 aircraft. And it's concentrating its advanced-engine development work on the J-93-3, an engine that burns hydrocarbons in both the turbojet and afterburner, with an eye to using this engine in the F-108 fighter interceptor that once was slated to use the "Dash Five" unit.

Russians Lack Chemical Equipment, Turn to West

Despite stiffening U. S. Commerce Dept. restrictions, the Russians are turning to the West with increasing success for chemical plants and equipment. Last month two more marks of their success were reported:

- A complete "ten-unit" synthetic rubber plant, costing over $1.4 million and to be located in Siberia, has been ordered by the Soviets from John Dagleish & Co., Glasgow, Scotland.
- A $1.8-million, 9,000-ton/yr. polystyrene plant will be delivered to the U.S.S.R. early next year by BX Plastics and P. G. Engineering, both British firms.

Behind moves such as these stands the fact that the Soviet Union clearly is unable to produce enough in the way of process equipment to meet the growing needs of its chemical industry. Though they have upped chemical equipment output by nearly 50% this year over last year, the Russians, by their own admission, are considerably short of what their "planners had expected." Recently, United Nations Economic Commission on Europe released a report that stated that Soviet chemical equipment production in the first six months of this year is only 28% of the country's goal.

As a result of this lack, the Russians are increasing their CPI purchases in the West. In 1958, their total plants and equipment imports amounted to $50 million; in 1959, Soviets have imported more than that from the United Kingdom companies alone.

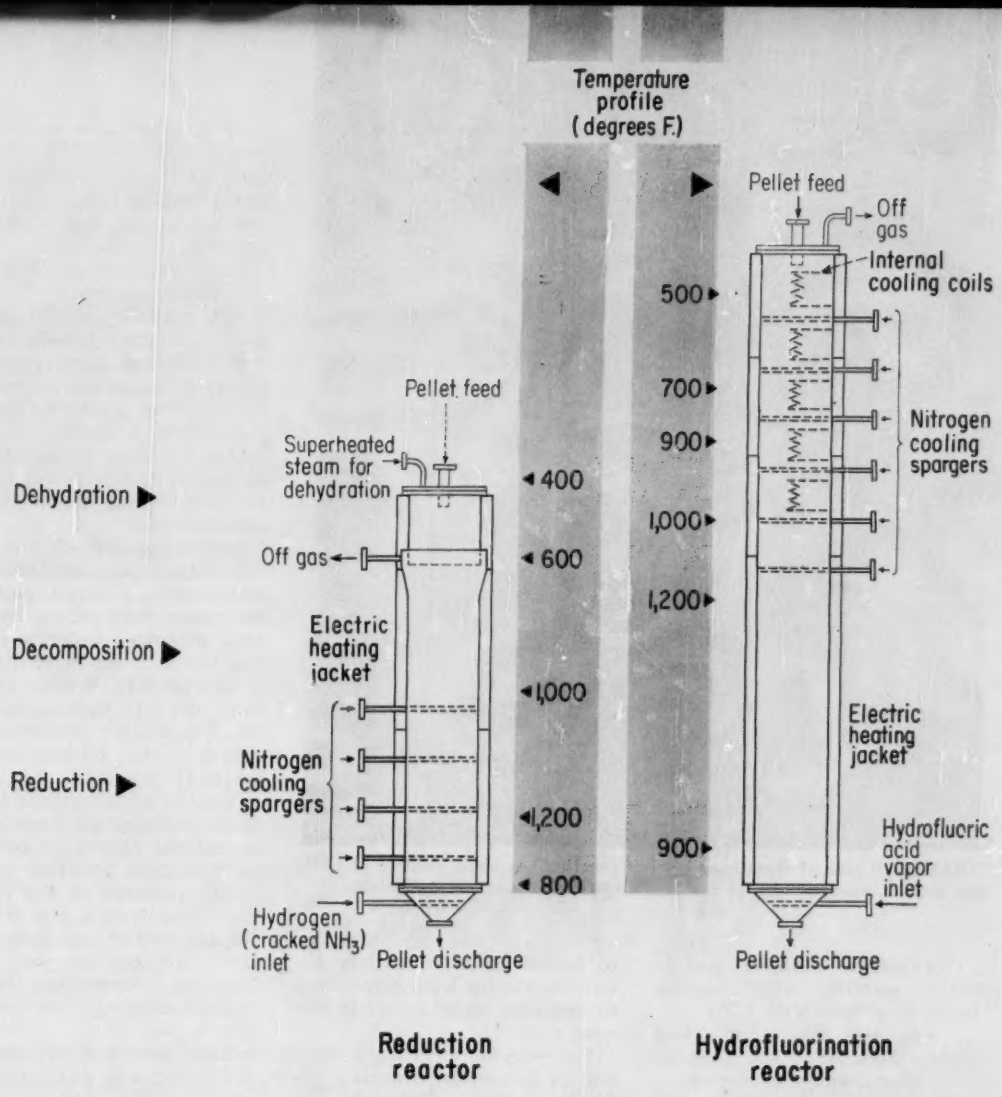
Novel Finishing Step Boosts Gold Recovery

A new finishing step, developed by Golden Cycle Corp., has boosted gold recovery from gold-bearing flotation tailings at the rate of $6,000/mo. at the company's Carlton Mill in Victor, Colo.

Tailings, containing some 5% of the total gold value produced in the Carlton Mill, are first treated in the usual low-grade cyanide circuit. Then gold in the cyanide pulp is adsorbed on activated charcoal, freed in a solution of hot caustic soda and sodium cyanide. This solution is then fed to an electrolytic cell where the gold is recovered.

In this specially constructed cell, designed by Golden Cycle engineers, the gold electroplates onto stainless steel wool. Cell consists of an inner molded-rubber basket perforated over its entire surface to permit passage of solution. A layer of stainless steel wire mesh is wrapped around the outside surface of the basket, and the steel wool surrounds this mesh.

Gold solution enters the cell through a hollow shaft. Shaft acts as the cell's anode, the stainless mesh as the cathode.



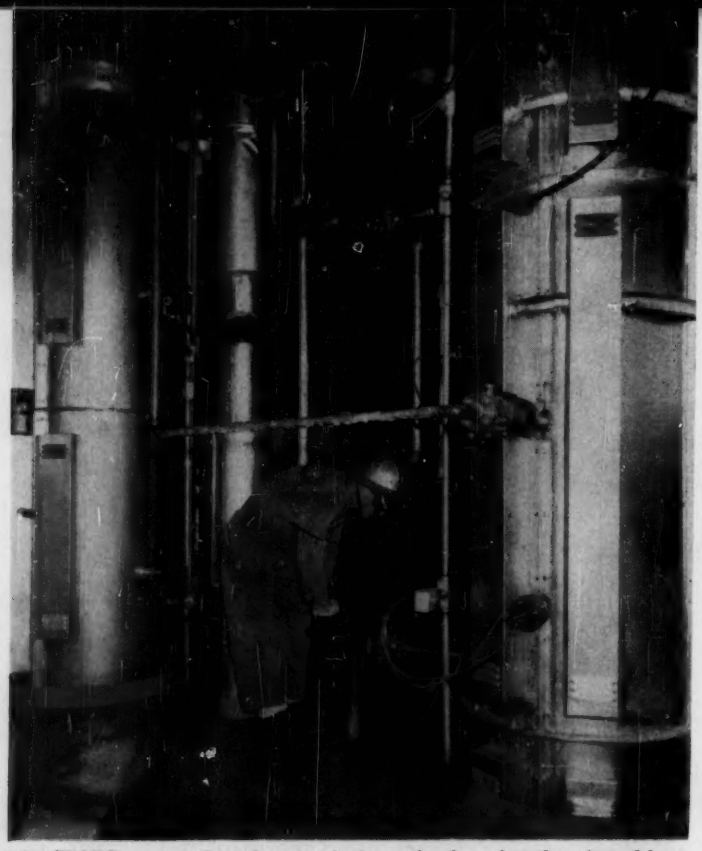
Moving Beds Unsnarl Tricky Reactions

Faced with a troublesome pair of gas-solid reactions, engineers select moving beds to boost efficiency and yield under precisely controlled profiled temperatures.

Cross fertilization from petroleum refining has borne fruit in metallurgical processing. At Port Hope, Ont., Eldorado Mining & Refining, Ltd., uses moving beds borrowed from petroleum technology to improve vastly the reduction and hydrofluorination of uranium ore concentrates.

Eldorado chose moving beds under the guidance of Catalytic Construction Co.'s process-wise George Holby rather than use the screw-type reactors common to uranium refining. With this move, Eldorado was able to:

- Gain roughly a four-fold rise in throughput per unit of reactor volume.
- Reduce HF consumption from the usual 205-240% of theoretical down to 105%, and H_2 consumption down to 96% from 250%.



REACTORS seen at third floor level of reaction bay show location of heating jackets, sparge lines for nitrogen coolant and thermocouple wells.

• Produce uniform specification material which consistently runs over 99% UF_4.

• Require substantially less maintenance labor and supplies than older uranium refineries.

▶ **What Reactors Do**—Eldorado's feed to the moving beds, ever since starting up in Jan. 1959, has been UO_3 or orange oxide extracted from crude ore concentrates by solvent. During reduction, the UO_3 reacts with hydrogen to form UO_2 (brown oxide).

$$UO_3.2H_2O \longrightarrow UO_3 + 2H_2O$$
$$UO_3 + H_2 \longrightarrow UO_2 + H_2O$$

Brown oxide from the reduction stage feeds to a second moving bed reactor for hydrofluorination to UF_4.

$$UO_2 + 4HF \longrightarrow UF_4 + 2H_2O$$

▶ **Need Complete Conversion**—In both of these reaction stages, it's important to operate within prescribed reactant and temperature gradients so that conversion will be essentially complete.

During reduction, temperature must approach, but not exceed, 1,050 F. This assures complete reduction of orange oxide to brown oxide to satisfy requirements for high conversion to uranium tetrafluoride in the next step.

But even more critical is control of temperature during hydrofluorination. Since the reaction is reversible, temperature is allowed to rise as the exothermic reaction proceeds in order to force it nearer completion. At the same time, the level must be kept below the equilibrium temperature to prevent fusing the solids.

▶ **A Perfect Match**—Eldorado's ability to handle these fussy conditions with the outstanding results mentioned earlier rests on a successful marriage of equipment to process.

For both the reduction and hydrofluorination, feed enters the moving-bed reactors continuously at the top, moving downward against upflowing gas. Finished product discharges continuously from the bottom.

Reactant gas flows into the bottom of each reactor through meter and rises countercurrent to solids flow. Thus, fresh gas contacts the product in a "polishing" zone at the bottom of the reactor to achieve high conversion.

Temperatures are measured by thermocouples in the bed which actuate current to the electric heating jackets or flow controllers on lines supplying nitrogen sparge gas for cooling. By breaking down this control function to a number of zones on each reactor, temperature is controlled to a profile from top to bottom, optimizing the reactions.

▶ **Pellets for Bed**—Before feeding orange oxide to the reduction reactor, Eldorado pelletizes the material by mixing in about 15% deionized water and casting the mixture in cavities on a moving belt. Within about 2 min., the UO_3 becomes a pellet of $UO_3.2H_2O$. Screening removes $-\frac{1}{4}$, $+\frac{3}{4}$-in. material which is recycled.

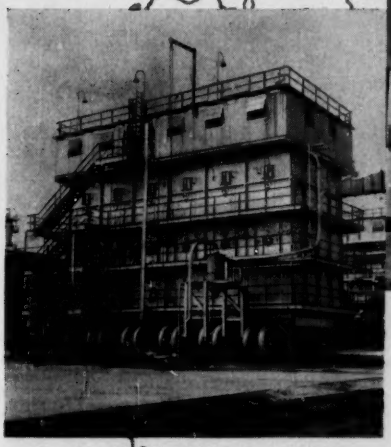
Quality of the pellets is vital to maintaining good moving-bed operation. They must be strong to withstand handling and the static pressure in the reactor. Any fines from pellet breakage impede flow of gas through the bed. Not only do good pellets keep the bed open but they also react completely for maximum conversion.

▶ **Built to Last**—In designing the reactors, Catalytic Construction Co. had to specify carefully the materials of construction which would withstand severe temperatures and corrosive conditions.

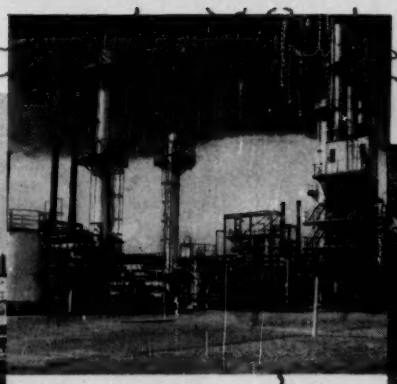
The upper 3-ft. dehydration zone (350-600 F.) of the 15 ft. by 14 in. reduction reactor has a $\frac{1}{4}$-in. Type 347 stainless steel shell. Below this point where temperature increases up to 1,050 F., the shell is Type 309S stainless steel.

In the 24 ft. by 14 in. hydrofluorination reactor, Inconel is used throughout. For addition to HF, this reactor must withstand moisture, produced by the reaction, and attack by sulfur compounds that may be present (Normally, sulfur content is negligible). Temperature of this unit exceeds that of the reduction reactor.

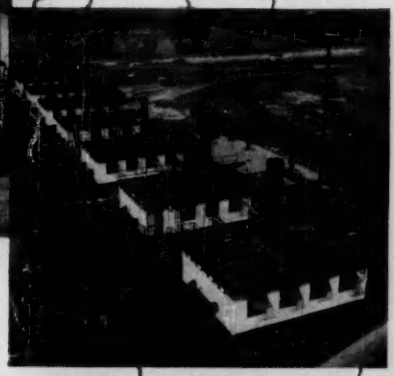
Processes & Technology continues on page 48.



One of two 15 million cubic feet per day Girdler hydrogen reformers at a Delaware refinery.



Girdler hydrogen plant, a part of catalytic reformer installation in Gilsonite, Colorado.



Three large hydrogen plants have been built at widely separated locations for the Nitrogen Division of Allied Chemical Corporation.

HYDROGEN

In the last decade, most of the hydrogen plants installed in the United States and Canada have been built by Girdler.

This performance alone provides undisputed evidence of Girdler's ability and know-how and assures you of dependable design, engineering and construction. You can count on Girdler to help you when you're considering a new plant, or enlarging your present facilities for producing hydrogen or synthesis gases for ammonia, methanol, oxo-process, etc.

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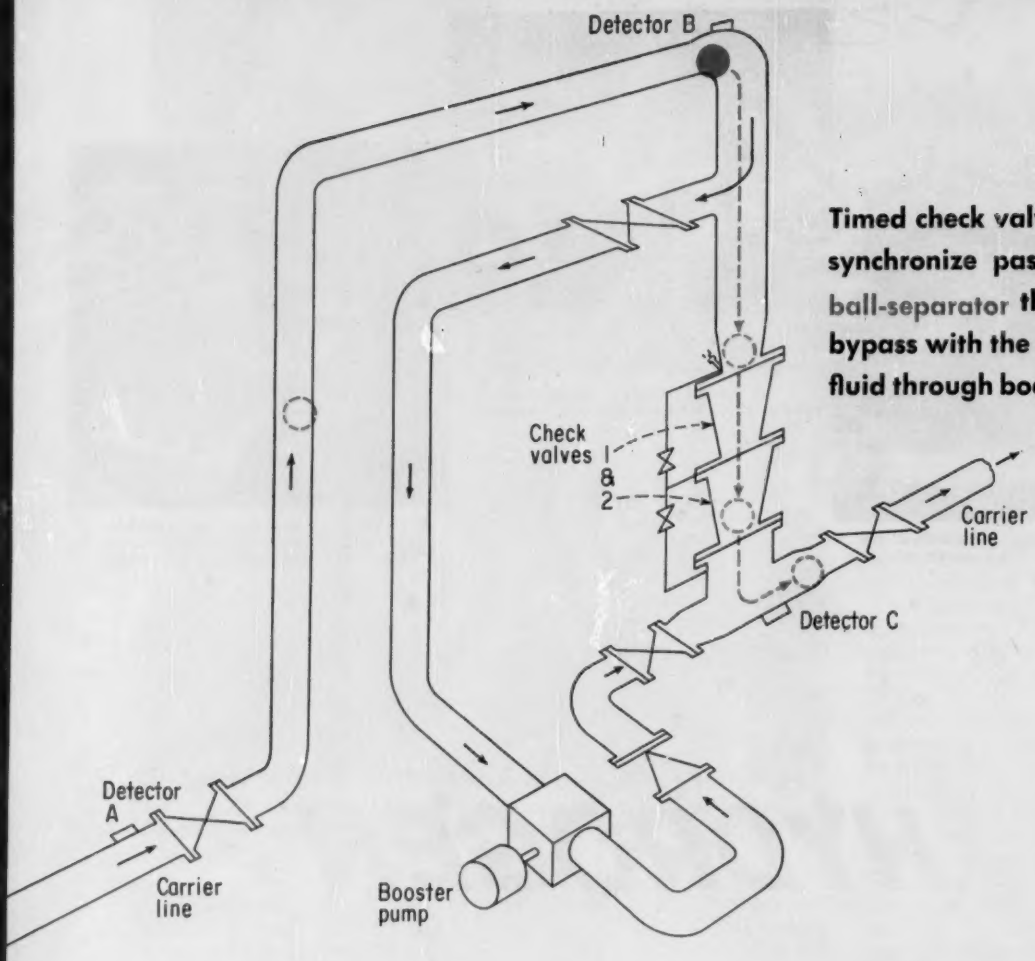
chemical processes and process plants



Timed check valves synchronize passage of ball-separator through bypass with the flow of fluid through booster pump.

Ball-Separators Reduce Pipeline Mixing

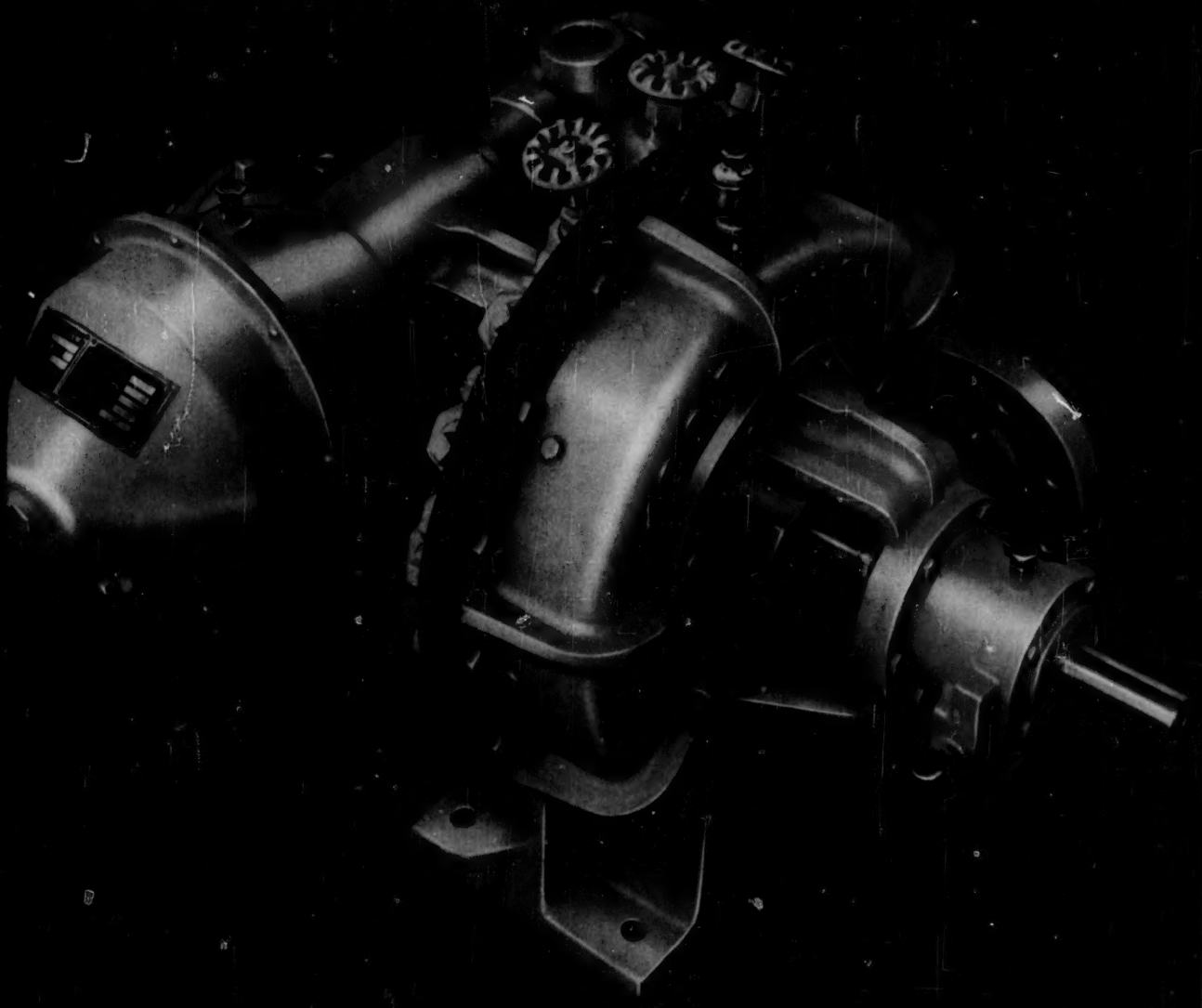
Balls replace dumbbells for separating products in 250-mile pipeline, and open the way to lower-cost automatic operation and reduced product losses.

Dumbbells help some. But inflatable elastomer balls are far better. So reports Shell Oil Co. in disclosing recently its use of balls in the North line between Wood River refinery and East Chicago, Ill.

Shell's pipeline spheroids drastically slash the cost of transferring petroleum products overland through the 14-in. pipeline. Without the balls, more than 1,000 bbl. of mixed products are produced at each interface during the 250-mi. transfer. With balls separating adjacent product slugs, mixing totals only 250 bbl.—a 75% improvement. Best dumbbell performance in the same line cuts mixing only 30% to 700 bbl. over the 250-mi. run.

► **Fabricate, Then Inflate**—In their search for an improved product separator, Shell engineers looked for a device that could be inserted into pipelines more easily and under more precise control than dumbbells. And they wanted a device that

COPPUS BLUE RIBBON PRODUCTS



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COPPUS
STEAM TURBINES

was cheaper to use, one that could bypass around pumping stations automatically.

Working in conjunction with F. H. Mahoney Co., a Houston manufacturer, Shell developed several experimental pipeline balls, some having hollow centers, some having aluminum and wood cores.

Hollow spheres that could be inflated gave best results. Natural rubber, neoprene and Hycar proved to be the best materials of construction.

After fabrication by molding and vulcanization, the balls are inflated to a diameter 1% larger than the pipeline's internal dimension, using either water or antifreeze. Gas cannot be used for inflation because fluctuations in line pressures will affect ball size.

▶**More Balls, Less Loss**—Relative effectiveness of either ball or dumbbell product separators varies directly with the number which can be inserted into line within reasonable time after passage of the interface.

Because the dumbbell doesn't manipulate and control easily during launching and at the booster-pump stations along the pipeline, only two dumbbells can be used at a given interface.

On the other hand, a ball, being compact, smooth and equidimensioned, is handled quickly by automatic launchers and automatic pump-station bypass mechanisms. More spherical separators can be positioned, therefore, per interface.

For example, to reduce mixing 75% along the North line, Shell places a total of five balls per interface, spaced at equal intervals of 120 ft. If the dollar loss per barrel of intermix were greater, Shell could increase the number of balls to effect maximum savings.

▶**Other Advantages**—In addition to product savings, pipeline balls cost less because they have a wear life of 800-1,000 mi., compared to a 60-70-mi. life for dumbbells. And the spheroids require a relatively small amount of fluid energy for movement.

Labor costs at either end of the line are not materially less. However, automatic bypass equipment has eliminated labor at the booster-pump stations.

▶**How Balls Are Launched**—Basically, the launcher is an oversize tee swedged into the pipeline and fed by an inclined-pipe ball magazine. When retaining plunger releases a ball from magazine, ball passes through a check valve and down tee into the pipeline.

As this ball travels downstream, it triggers a strategically located detector (usually about 120 ft. from the launcher) that signals release of the second ball, and so on. Up to 10 balls can be automatically launched in this manner, at intervals of less than 15 sec. Each falls into progressively purer liquid, the last presumably into completely unmixed product.

▶**Bypassing Pump Stations**—Essential features of a Shell automatic bypass mechanism are shown in sketch. The piping from detector *A* to detector *B* will hold the same liquid volume as the piping, pump and fittings between detector *B* and detector *C*.

In operation, time required for passage of a ball from *A* to *B* is indexed into a control circuit. As the ball passes *B* to drop into check valve *1*, the circuit starts an operational sequence that drops the ball through check valve *2* and back into the pump's discharge stream in the same relative position it held at *B*.

During this shunting operation, the pump runs at full speed; no flow passes through the check valves. Minimum cycling time, about 23 sec., is one factor predetermining ball spacing at the launcher.

While Shell acknowledges that spheroidal separation is yet in its infancy, the first full year of operations on the North line give sound reason to believe that pipeline balls are here to stay.

Western Canada's Waste Wood to Move in Spheres

Up in the big-timber country around Kamloops, B. C., inland sawmills and plywood plants may soon be converting their waste wood into chips for sale to distant pulp mills on the coast. And 250-cu. ft. plastic balls will play a big part if current hopes are realized.

Still in the experimental stage, the radical scheme involves loading the chips into the huge spheres, which will then be released to go bobbing down fast-running Fraser River. At the end of the cruise, coastal pulp mills will snare the balls, empty them, and return them in dismantled form by land transport.

First prototype, sponsored by Crown Zellerbach Canada timber division, consisted of two flanged and bolted hemispheres made of ⅛-in. plastic, reinforced with glass fibers. In the first run, the ball traveled about 50 mi. before planned pickup. It was bruised, but the chips were dry. Other runs are in the works.

Another firm, Puget Sound Pulp & Timber Co., is performing similar studies with rubber bags.

Describing the project as "a huge breakthrough for the Kamloops forest industries," Forest Minister R. Williston estimates that 30% of each tree cut is left on the ground, and another 29% is wasted at the mill. With a wood-chip shortage on the coast, the new river carriers could well turn this waste into ready cash.

Cotton, Pro and Con For Chemicals Marketers

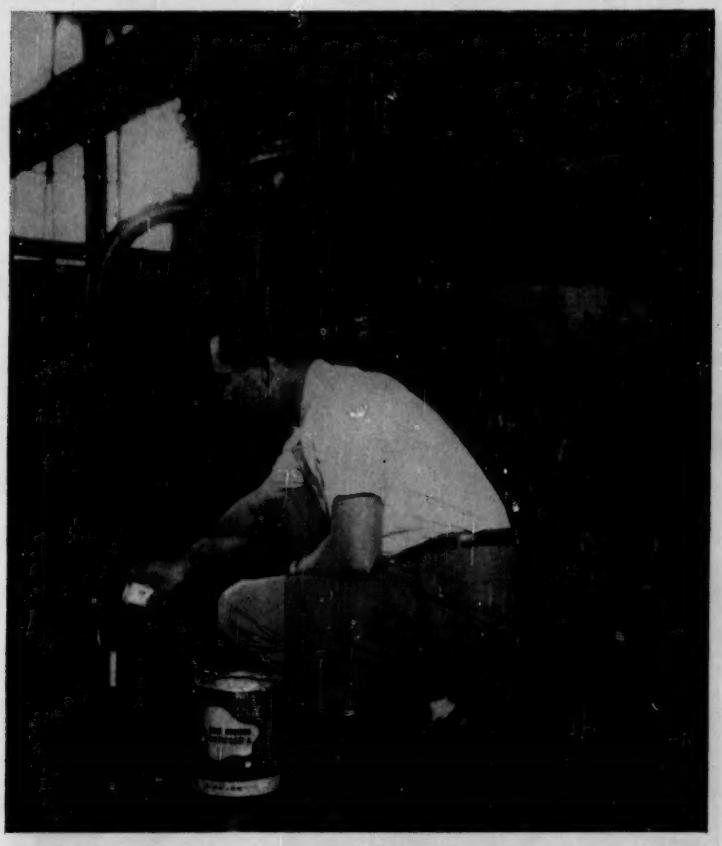
Not only have wash-and-wear synthetic fibers created a new primary market for chemicals, their competition has stimulated a new secondary market of impressive proportions. According to preliminary industry estimates, 2 billion sq. yd. of cotton fabric were treated with resins for wrinkle resistance in 1959. This compares with 0.6 million in 1950. Production figures comfortably exceed those of all synthetic fibers combined.

Treatments consist mostly of resin monomers such as urea formaldehyde. Treating fabric for wrinkle resistance costs 5-10¢/yd. compared to 1½-3¢ for conventional cotton treatment.

Though undoubtedly still king, cotton is still subject to improvement: USDA has just reported

SILICONE NEWS from Dow Corning

Costs Go Down with Foam



IN VARNISH COOKING

Job-proved as fastest and most effective for all processing operations, Dow Corning silicone defoamers are available in different forms for different systems. Why not make tests on the materials that are giving you foam problems?

A generous trial sample is yours for the asking. Write for this FREE SAMPLE, giving an indication of your problem and the type of system — oil, aqueous, non-aqueous, food product or other. Address Dept. 2601 for prompt reply.

Silicone Defoamer Beats Down Foam ...Defeats High Maintenance Cost

The chief engineer of a southern chemical plant periodically met real bugbears—foam boil-overs in a methanol-wood oil fractional distillation system. Such occurences meant shutting down the still, while over 600 man hours were spent putting the unit back in condition.

That was before testing silicone defoamers. Now, foam's completely eliminated simply by adding only 5 parts per million of Dow Corning Antifoam A. Boil-over clean-up man hours are nil. The chief engineer champions this silicone defoamer as the most effective system — says, "Without it, I'd simply go crazy."

If foam is fouling up your processing, putting you behind schedule and leaving you with too high a ratio of waste material, chances are you can lick foam once and for all — realize noteworthy savings through the use of Dow Corning silicone defoamers. Easy to use and economical, these silicone defoamers are widely used to overcome foam problems in processing varnish, paints, adhesives, asphalt, textile dyes, petrochemicals, foods and many other products.

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successful experiments suggesting nuclear radiation as a broad new tool for chemical modification. Cotton cellulose, which has very low chemical reactivity, had acrylonitrile polymerized onto it by gamma radiation. Electron microscopic examination of the cotton indicated the polyacrylonitrile was located within the fiber at the inner part of the cell wall, extending completely around the lumen of the fiber.

Acrylonitrile played a role in another new fiber development this month. Kurashiki Rayon of Japan is preparing to offer an unusual new fiber called Lombel made of a polymerized rayon staple and acrylonitrile. Only similar fiber in this country was described in reports of research at Princeton involving cospinning acrylonitrile and rayon.

Polyethylene Back in Polyolefin Spotlight

Though the big plastic play these days is being given to the "higher" polyolefins like polypropylene and polybutylene, the material that started it all isn't being neglected.

Goodrich-Gulf, after studying the entire range of polyolefins, has elected to get into the business with polyethylene. Company reports construction start on a 13-million-lb./yr. high-density polyethylene plant at Port Neches, Tex., slated on stream late in 1960. And Owens-Illinois announces that it plans to expand production of high-density polyethylene containers at Kansas City, Mo., St. Charles, Ill., and Glassboro, N. J.

Goodrich-Gulf claims it has developed its own new process to the polyolefin based on Zeigler chemistry and four years of pilot planting. Route turns out material that's said to have outstanding stress-crack and thermal resistance. Markets eyed: Bottle, pipe, wire and cable applications. O-I's move reflects "overwhelming reception by makers of liquid detergents, household cleaners and other household products" to semi-rigid plastic bottles made from the high-density plastic.

INDUSTRY NEWS

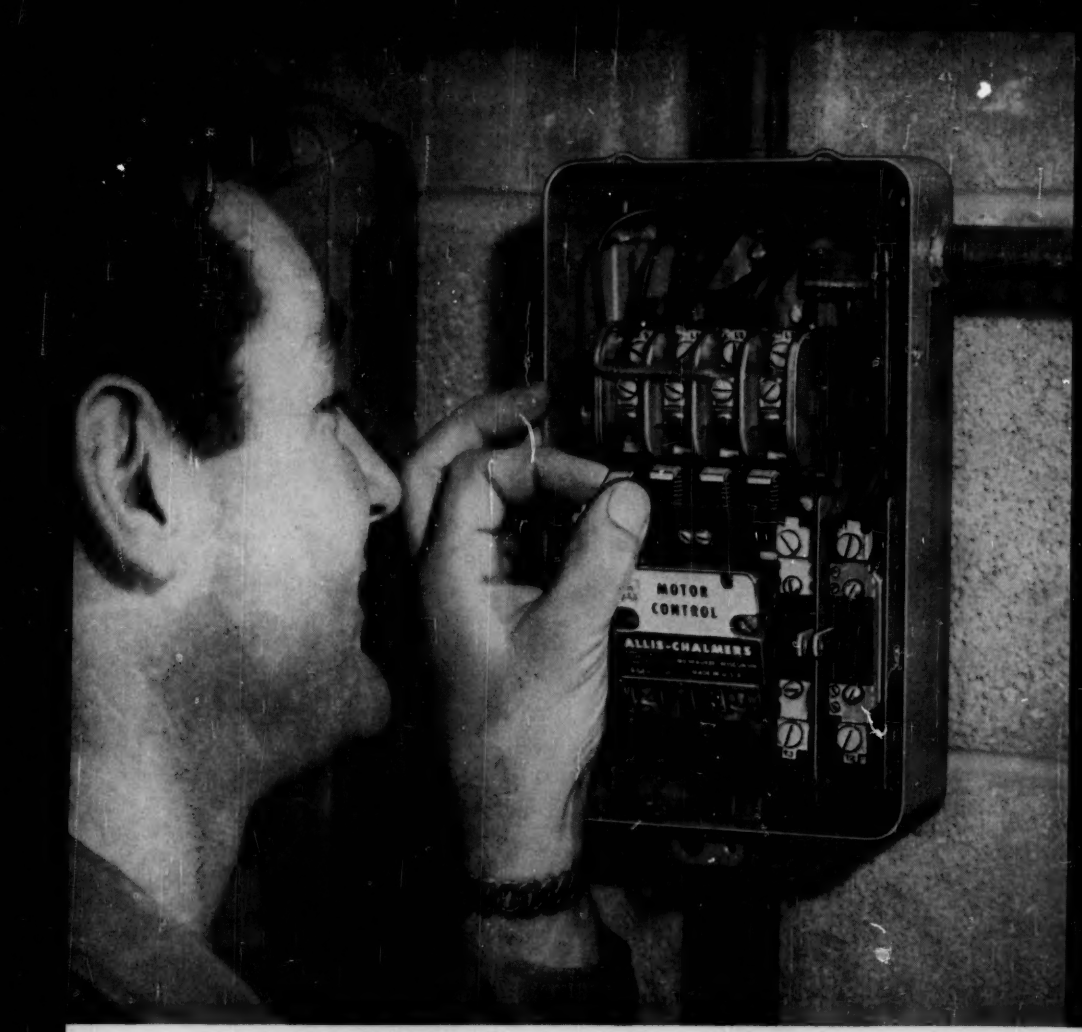
GIANT hoppers hold dust in new Columbia-Southern plant.

Columbia Southern Chemical Corp. has just put into operation its new 1.5-million-bbl./yr., electronically controlled cement plant at Barberton, Ohio. Modern plant features gigantic, 460-ft long rotary kiln, electronically controlled ball-mill feeder and an elaborate automatic dust-control system. Latter system includes 18 dust collectors and hoppers, several of which are shown above, to discharge potential air pollutants to a water stream.

Dow Chemical Co. announces plans for construction of an 18,000-ton/yr. phenol plant in the Pacific Northwest. Dow officials have secured options on land near Longview, Wash., and Portland, Ore., will soon select the ultimate plant site.

Hercules Powder Co. is now undertaking a multimillion dollar expansion of its Hercules, Calif., plant. Urea-formaldehyde capacity expansion will be completed by August;

Industry News continues on page 152.



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NEW complete line of low voltage motor control

Wide-open accessibility and modern design assure fast and easy installation, modification, inspection and maintenance of this new line of Size 0 through 4 Allis-Chalmers control. For instance, large and clearly marked terminals, pressure connections for all wiring, wide and deep-cut screw slots, clearly visible contacts, easy coil replacement, readable rating plates, "out-front" overload relays.

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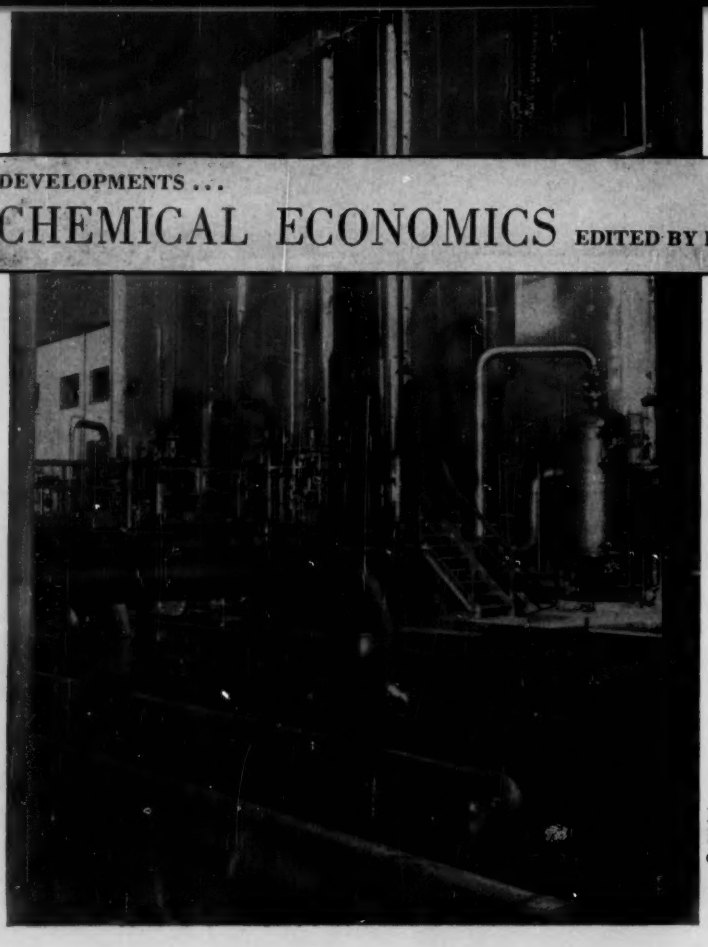

NEW low-temperature units at Keyes, Okla., double U. S. output of vital helium.

Industrial Gases Ride Technology Boom

- OXYGEN: Steel makers want another 30 million cu. ft./yr.
- NITROGEN, ARGON: Inert atmospheres for space-age metal working
- HELIUM, HYDROGEN: No low, low temperatures without them

John B. Bacon, Assistant Editor

As advancing technology proliferates, especially in the metal and chemical industries, it primes growth in a relatively young, vigorous field, industrial gases. For these gases—oxygen, nitrogen, hydrogen, helium, argon—technology is the life blood.

Now, after a couple years of quiet, steady growth for most of these gases, technological priming promises to touch off one of the most spectacular growth years ever. There was 1958's recession and 1959's steel strike; so, barring a lengthy resumption of the strike, demand for all gases will show a sharp increase.

First, for comparison, here are estimates for 1959 production: Oxygen, 90.4 billion cu. ft. —up about 8% from 1958; nitrogen, 13 billion cu. ft—a 96% leap from 1958; hydrogen 52 billion cu. ft.—up 13%; argon up 7.5% to 400 million cu. ft.; helium up nearly 14% to 380 million cu. ft. With the exception of oxygen, these figures don't include production for government and captive use.

The real eye-opener, though, is a rundown of forecasts for this year: Oxygen is scheduled for a whopping 30% rise to nearly 120 billion cu. ft.; nitrogen should climb about 25%; hydrogen, about 10%; helium, a healthy 60% (because of one new plant recently on stream

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1,3-Butylene Glycol is a low-cost, 4-carbon glycol with unusual stability. Its combination of two non-adjacent hydroxyl groups prevents dehydration or ring closure. It is highly hygroscopic, non-toxic and soluble in water and most organic solvents.

1,3-Butylene Glycol's longer chain length and steric configuration open new possibilities for producers of textile lubricants, printing inks, dyes, cosmetics, toilet goods, elastomers, plasticizers and alkyd, polyurethane and polyester resins.

It is of particular interest in the preparation of phthalic, maleic and fumaric alkyd resins and polyesters for plasticizers, coating materials, laminates, and potting compounds.

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POLYURETHANES—Saturated polyesters can be prepared from 1,3-Butylene Glycol with various polyfunctional acids and alcohols.

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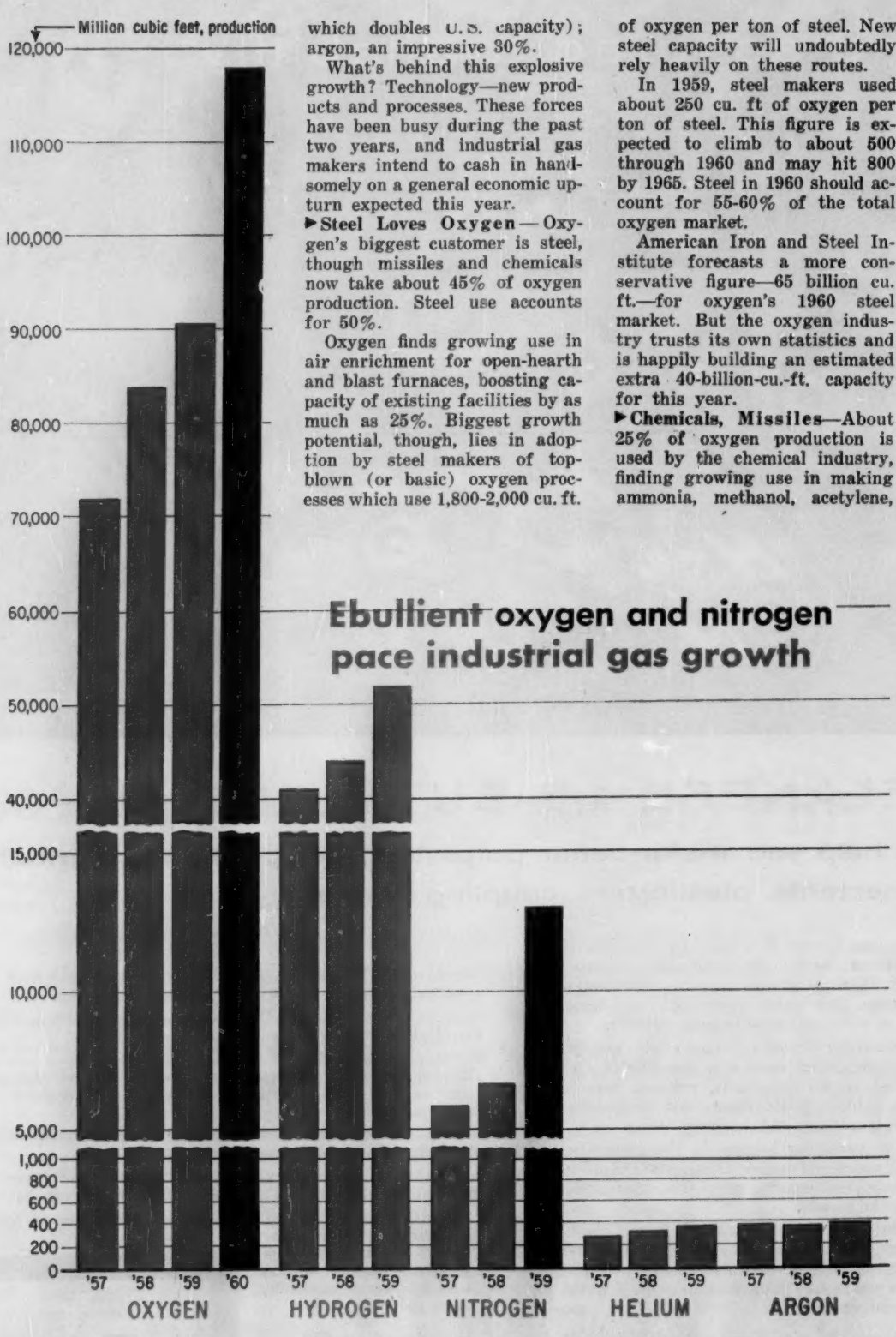

Ebullient oxygen and nitrogen pace industrial gas growth

which doubles U.S. capacity); argon, an impressive 30%.

What's behind this explosive growth? Technology—new products and processes. These forces have been busy during the past two years, and industrial gas makers intend to cash in handsomely on a general economic upturn expected this year.

▶**Steel Loves Oxygen**—Oxygen's biggest customer is steel, though missiles and chemicals now take about 45% of oxygen production. Steel use accounts for 50%.

Oxygen finds growing use in air enrichment for open-hearth and blast furnaces, boosting capacity of existing facilities by as much as 25%. Biggest growth potential, though, lies in adoption by steel makers of top-blown (or basic) oxygen processes which use 1,800-2,000 cu. ft. of oxygen per ton of steel. New steel capacity will undoubtedly rely heavily on these routes.

In 1959, steel makers used about 250 cu. ft of oxygen per ton of steel. This figure is expected to climb to about 500 through 1960 and may hit 800 by 1965. Steel in 1960 should account for 55-60% of the total oxygen market.

American Iron and Steel Institute forecasts a more conservative figure—65 billion cu. ft.—for oxygen's 1960 steel market. But the oxygen industry trusts its own statistics and is happily building an estimated extra 40-billion-cu.-ft. capacity for this year.

▶**Chemicals, Missiles**—About 25% of oxygen production is used by the chemical industry, finding growing use in making ammonia, methanol, acetylene,

All these PROTECTIVE features are a part of the H-25 PAYLOADER®

"The more than 10,000 small 'PAYLOADER' tractor-shovels that we have produced for steel mills, foundries, chemical and fertilizer plants usually operate under exposure to dust, dirt, powder and foreign materials," says Ralph Beyerstedt, Executive Vice-President of The Frank G. Hough Co.

"During the development of the H-25, as soon as it became evident that we were going to obtain the increased capacity, production, operating ease, speed and mobility we sought, our engineers then gave major attention to *protective features* for operational insurance against wear, maintenance delays, abuse, downtime and the like."

Dozens of Protective Features

"We started by giving the engine maximum protection with a triple air cleaning system, cartridge-type oil filter, sealed ignition and starter switches, a 12-volt electric system with sealed generator, solder coated terminals and a clutch-pressure warning device. The filtered hydraulic system is closed and pressure controlled and the majority of all major pivot points in the boom arm mechanism, the gearshift and steering linkage are sealed."

What About H-25 Production?

"Most important of all, the operating capacity of the H-25 is 2,500 lbs.—25% greater than has ever before been available in a tractor-shovel of its size and maneuverability. It is the only loader in its size range with *complete* powershift transmission—having 2 speed ranges forward and 2 in reverse. Power steering also is standard.

"Other plus features of the H-25 that mean more production, long life and less maintenance are the exclusive power-transfer differential, wet-sleeve overhead valve engine, 4,500 lbs. of bucket breakout force and 40° bucket tip back at ground level."

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acrylonitrile. It's used to oxidize select hydrocarbons to aldehydes, acids and alcohols. This market, too, is expected to grow.

One example of new-technology's demand on oxygen is the Shell ethylene oxide route, using oxygen instead of air. There's been debate about which oxidant is better (*Chem. Eng.*, July 28, 1958, pp. 100-104), but, according to some, the Shell process has been improved of late and may find more takers. Texaco's partial oxidation (with oxygen) of methane or fuel oil makes hydrogen for new ammonia plants and is the basis of the Air Force's new liquid hydrogen plants. A future use of oxygen, according to Air Products' J. Ernest Nachod, is in high-temperature flames for producing, in extremely short residence times, free radicals which may be controlled to give a desired product.

Of course oxygen use for fuels in the missile industry is a sizable fraction of the total oxygen market. Guesses peg current use at about 1,700 tons/day.

There's some feeling that the missile market may be nearing saturation, or even a decline, as missiles are set on launching sites. But one industry man counters this by pointing out that as hydrogen rockets enter the development stage (a hydrogen-consuming rocket engine is expected possibly in a matter of a few months) increasing amounts of oxygen will be needed.

As oxygen capacity mounts so does that for nitrogen and argon.

▶ **Boots for Nitrogen**—Nitrogen, excluding that used in making ammonia, showed an exceptionally big growth spurt in 1959. Fastest growing market segments are missiles and chemicals industry. Use as an an inert gas in purging and as a raw material for acrylonitrile figure heavily in consumption.

Nitrogen finds growing use, too, in metals industries—bright annealing of steel, chilling in aluminum foundaries, for example.

One particularly fast-growing market is government requirement for missile and space programs—blanketing, purging, testing for leaks, inert pressure medium for propellant-feed systems. Trend here is to get more nitrogen out of existing air-separation plants. Where the earlier requirement was about 10% nitrogen, 90% oxygen, the need now is for about 40% nitrogen, 60% oxygen.

▶ **Argon Leads**—Argon has seen the fastest growth of all industrial gases over the past several years. And 1960 promises a record increase, an estimated 30%, to nearly 600 million cu. ft.

Shielded-arc welding of stainless steel, aluminum and other metals is on the increase. Need for inert atmospheres in working metals for nuclear and space-age requirements will take a larger hunk of argon.

In a potentially significant development, steel makers have been quietly working on use of argon to cut down impurities while pouring ingots. Typical need here is about 10-15 cu. ft. of argon per ingot ton. Casting with argon gives better forgibility.

▶ **Cryogenic Gases**—Helium and hydrogen (excluding that used in petroleum refining) have been in the news a good deal as cryogenic gases. These markets will see a lot of growth in the next few years.

Biggest share of noncaptive hydrogen goes, of course, to hydrogenation of edible fats and oils. Direct reduction of iron ore has spurred some market growth. There's a growing trend, moreover, to hydrogen atmosphere in such other metallurgical work as fabrication and alloys.

Helium's prime market is government work. Yet it's finding good growth in civilian markets, shielded-arc welding, inert-atmosphere processing, low-temperature research.

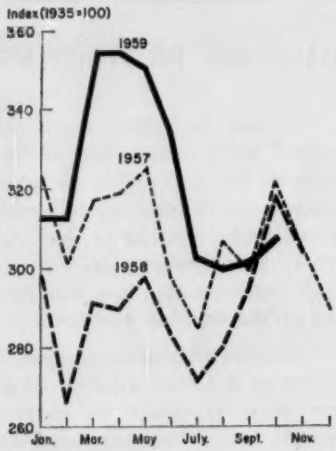
▶ **For Tomorrow**—Here's a small sampling of present technological activity that could easily spur market growth for industrial gases in the future.

Avco Corp. and 10 utility companies are working on an experimental device to use magnetohydrodynamics to generate electricity. When atomic energy is used as a heat source, helium or argon, with 1% cesium seeding, is used as a working fluid (gas ionizes at high temperatures, is passed through a magnetic field to generate current). Thermal efficiency is 55%, compared with 40% for an armature and the necessary turbine.

New electronic devices such as the infrared detector and the maser must operate at extremely low temperatures. For these, helium is used as refrigerating gas. In other cases, nitrogen can be used.

One extremely interesting device is North American Philips' Cryogenerator, or Norelco Liquifier, a closed system gas refrigeration cycle. It is completely self-contained; no external source of working fluid is required. (See *Chem. Eng.*, Nov. 30, 1959, p. 82.) In effect, it is a portable source of refrigeration. Large four-cylinder Cryogenerators now in production can produce 170,000 Btu./hr. at 77 K. at very high efficiencies.

Chemical Consumption



Consumption by Industries

	June (Final)	July (Final)	Aug. (Final)
Coal products	10.4	3.7	2.2
Explosives	11.5	10.3	10.7
Fertilizer	63.0	56.3	59.5
Glass	29.6	29.9	32.2
Iron & steel	20.0	9.7	2.6
Leather	4.4	4.7	4.4
Paint & varnish	42.3	40.1	38.1
Petroleum ref.	31.2	31.9	32.7
Plastics	32.1	33.1	31.0
Pulp & paper	41.2	37.9	42.4
Rayon	28.1	27.8	27.6
Rubber	7.8	7.8	7.5
Textiles	10.2	9.9	10.3
Total	**332**	**303**	**301**

Served 6 years on a "6-month job"

Even special alloy pipe lasted a scant six months on this job: carrying highly abrasive phosphate slurry at a Florida refinery. That meant recurring shutdowns—costly replacement.

But the G.T.M.—Goodyear Technical Man—had another idea: Pipe protected with specially compounded PLIOWELD. This super-tough lining defies the destructive action of a wide range of abrasives and corrosives.

In fact, at last report, the pipe lined with PLIOWELD had already put in 6 years of service—*12 times as long as its predecessor*—with no breakdowns—no replacements. And it looked good for years' more service.

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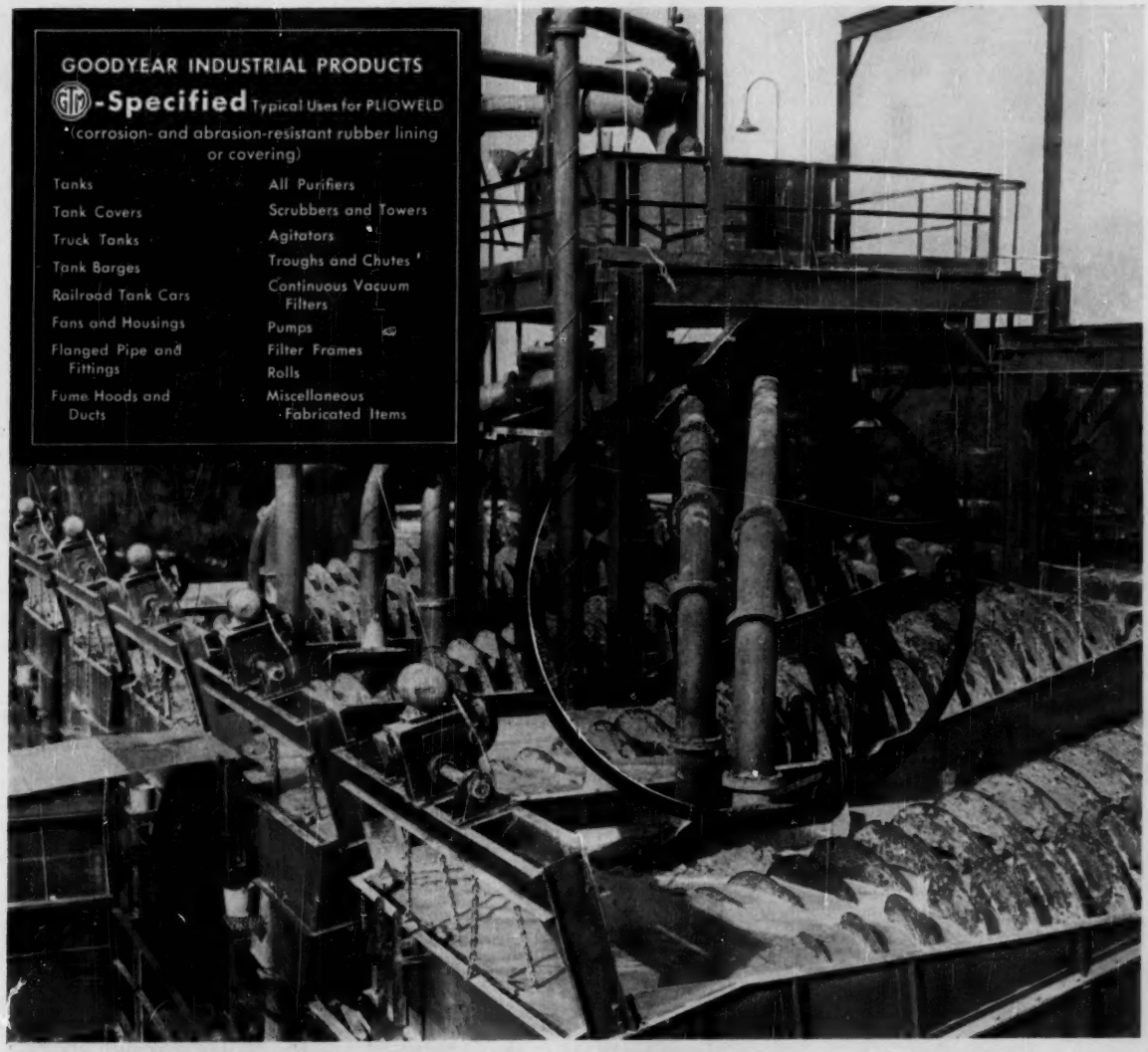

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Extruded in 0.002 to 0.060 thickness.

Extruded nylon film in a variety of thicknesses is currently being marketed. The new product possesses all of the chemical, physical and mechanical properties of nylon, making it useful to a wide variety of industries.

The film and sheet is now being offered in thicknesses from 0.002 in. to 0.060 in. and in widths up to 18 in. The material is grease, abrasion and vapor resistant, has a low coefficient of friction, a low permeability factor, and it can be steam sterilized.

The nylon film is being used as a food wrapping, particularly as a packaging material for meats, since individual cuts of meat can be enclosed in heat-sealed envelopes to guard against incursion of impurities and loss of flavor.—**U. S. Gasket Co., Camden, N. J.** 60A

Surfactant

Stable in caustic composition for long periods.

A new alkyl phenyl polyethylene glycol ether surfactant, Tergitol Nonionic E-35, is now available in developmental quantities. This nonionic surfactant was developed specifically for use with dry alkaline materials such as flake caustic or sodium metasilicate.

The surfactant is stable and does not discolor when stored in flake caustic compositions for prolonged periods of time at up to 50 C. Its low-foaming and good wetting properties suggest its use for bottle washing, metal cleaning, and automatic dish-washing detergent formulations. The surfactant aids dissolution of the dry alkaline material in water, improves the wetting and penetration of grease and soil in the cleaning operations and, as the concentration of electrolyte is reduced during rinsing, promotes streak-free drying by lowering the surface tension.—**Union Carbide Chemicals Co., New York.** 60B

Anode Material

Ti plated with Pt film proposed for chlorine-caustic cells.

A new material for electrochemical anodes, titanium plated with a thin film of platinum, has been suggested as a replacement of graphite anodes in chlorine-caustic cells.

By coating titanium with platinum, less than 1/10,000 in. thick, titanium can be made to act like a solid platinum anode. This may prove valuable in cathodic protection, electroplating, control devices and in many electrochemical processes.

The novel anode may find large scale use in the chlorine-caustic industry because it will provide a maintenance-free cell. Present graphite anodes are consumable-type and are consumed during operation of the cell. This causes expensive teardown of cells, results in higher operating voltages and leads to contamination of the chlorine. This new composite titanium-platinum anode eliminates these disadvantages and appears to provide savings in anode cost/ton of chlorine produced. —**Crucible Steel Co. of America, Pittsburgh, Pa.** 60C

Epoxy Adhesive

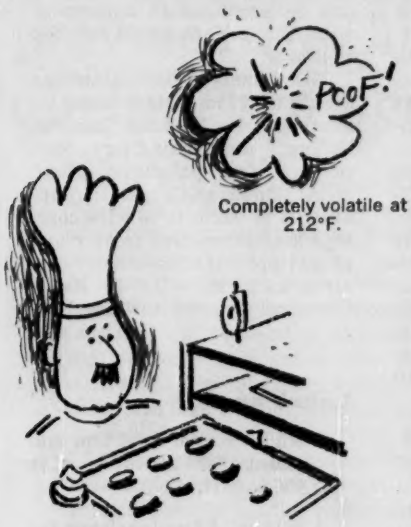
Costs a third as much as similar products.

A room-temperature-curing epoxy adhesive, Bondmaster M685, developed for the bonding of rigid expanded polystyrene foams to themselves, to metal, wood and other materials, is available from a half to a third the cost normally associated with equivalent products in the same chemical family.

The new product is a two-part, 100%-reactive, room-temperature-curing formulation that is available in free-flowing viscosity which permits simplified brush application.

Though it was formulated as an intermediate-strength structural adhesive, field tests have indicated applicability for economical metal-to-metal and metal-to-plastics general purpose bonding where strengths of the epoxy order are called for.

You just can't imagine the variety of things done with **SOLVAY AMMONIUM BICARBONATE!**



Completely volatile at 212°F.

Produces lots of gas for leavening

Safe, stable, dry source of ammonia

Neutralizes with low pH

(No wonder chrome tanners love it!)

Forms highly soluble end products

Almost infinite are the number of uses you can derive from the varied properties of Solvay® Ammonium Bicarbonate!

Tanners and cosmetic makers alike favor its high acid neutralizing value. To understand why, compare the pH of 1% solutions of ammonium bicarbonate, sodium bicarbonate and borax—**7.8**, 8.2 and 9.2 respectively! Bakers regard it as a wonderful leavener, because **one** pound will produce 14 cu. ft. of gas at oven temperatures (300°F.). Producers of chemicals and pharmaceuticals value it as a safe, stable, dry source of ammonia and a very soluble, mild alkali.

Perhaps a study of its properties and a test sample will reveal new or different facets of Solvay Ammonium Bicarbonate to you.

Physical and Chemical Properties

Molecular Weight 79.06
Solubility in Water. 14% at 10°C., 17.4% at 20°C., and 21.3% at 30°C.—Insoluble in alcohol.
Negative heat of solution.
Stability: Relatively stable at room temperatures.
Volatility increases sharply above 140°F.

Decomposition product ratios are as follows:

Ammonia gas (NH_3) 21.5%
Carbon dioxide gas (CO_2) 55.7%
Water vapor (H_2O) 22.8%
pH of 1/10 N solution at 25°C.: 7.8
Appearance: White crystals.
Quality: Exceptionally pure. Food grade.
Very low metal content.

Sodium Nitrite • Caustic Soda • Calcium Chloride • Chlorine • Chloroform Caustic Potash • Potassium Carbonate • Sodium Bicarbonate • Soda Ash Ammonium Chloride • Methyl Chloride • Ammonium Bicarbonate • Vinyl Chloride Methylene Chloride • Cleaning Compounds • Hydrogen Peroxide • Aluminum Chloride • Mutual® Chromium Chemicals • Snowflake® Crystals • Monochlorobenzene • Ortho-dichlorobenzene • Para-dichlorobenzene • Carbon Tetrachloride

Allied Chemical

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N. Y.

SOLVAY® branch offices and dealers are located in major centers from coast to coast. Send export inquiries to Allied Chemical International, 40 Rector St., N. Y. 6.

SOLVAY PROCESS DIVISION DR-10
Allied Chemical Corporation
61 Broadway, New York 6, N. Y.

Please send without obligation:
☐ Test sample of Solvay Ammonium Bicarbonate.
☐ Specific information requested in my attached letter.

Name_____
Position_____
Company_____
Phone_____
Address_____
City_____ Zone____ State_____

In six-drum lots, the mixed cost of Bondmaster M685 and its hardener ranges in the neighborhood of $7.75/gal. At this price, the cost/sq. ft. of a bonded surface with a glue line 0.005 in. thick is 2.4¢.—**Rubber & Asbestos Corp., Bloomfield, N. J.** 60D

ABS Resin

Improved acrylonitrile-butadiene-styrene for rigid pipe.

Cycolac LL, recently developed specifically for extruding rigid plastic pipe, represents an improved type of acrylonitrile-butadiene-styrene material. Outstanding properties include superior impact strength at normal and low temperatures, combined with excellent long term burst strength (*Chem. Eng.*, Mar. 23, 1959, p. 151).

Cycolac LL is equivalent or superior to the conventional ABS Type I materials in all respects. Pipe made of Cycolac LL does not equal the ABS Type II Cycolac C pipe in long term fiber stress and rigidity. However, where properties of superior impact, resistance to abuse or greater ductility are required, the LL material should be considered.

Processing characteristics are comparable to those of the ABS Type I resins, and both Type I and Type II fittings can be used satisfactorily.—**Marbon Chemical Div., Borg-Warner Corp., Washington, W. Va.** 62A

Rare Earths

High purity metals now available as powder.

For the first time in the industry, high purity misch metal, cerium, lanthanum, didymium and other rare earth metals and alloys are available in the form of finely divided powders.

These rare earth metals, in purities of 99.5% to 99.9%, are also produced in the form of ingot, rod, pellet and turnings.

The powders are available in any desired size down to −325 mesh. Such powders are useful for research in preparation of powder metallurgical products, including alloys impossible to make by conventional means. This is particularly important when research quantities of unusual alloys are required.

Fields in which such rare earth alloys are useful are missile and rocket propellants, pyrophoric alloys, flash powders for photographic purposes, components for electronic tubes, solid state devices, thermoelectric products.—**Cerium Metals & Alloys Div., Ronson Metals Corp., Newark, N. J.** 62B

Aluminas

Finely divided for dentifrices, lapping, honing, grinding compounds.

Four high-purity, finally divided alpha and gamma aluminas have been developed. Each type is controlled within a narrow range of particle size. The alpha aluminas vary from 0.02 to 0.4 microns and from 99.7% min. to 99.96% min. Al_2O_3.

In addition, a wide range of other micron sizes and purities can be produced in agreement with the requirements of the customer.

These finely divided aluminas are finding important uses in dentrifrices; lapping, honing, buffing, and grinding compounds for polishing glass, metal, stone, and crystal; preparation of radio tube wire coatings and fluorescent lamp phosphors; electrical ceramics; catalyst carriers.—**J. T. Baker Chemical Co., Phillipsburg, N. J.** 62C

Lubricant

High vacuum solid film lubricant for altitudes over 100,000 ft.

A new solid film lubricant for use in vacuum (high altitudes) has been developed. A ceramic-bonded molybdenum disulfide, it has been designated Lube-Lok 1005.

It has been tested successfully on moving parts of satellite cameras and other bearing surfaces in test chambers at altitudes in excess of 100,000 ft.

Newsworthy Chemicals

	Page Number is also Reader Service Code Number
Nylon film extruded in a variety of thicknesses	60A
Nonionic surfactant remains stable at 50 C	60B
New anode material proposed for chlorine-caustic cells	60C
Epoxy adhesive costs a third of similar products	60D
Acrylonitrile-butadiene-styrene improved for pipe use	62A
Rare earths of purity now available as powder	62B
Aluminas controlled in narrow range of particle size	62C
Lubricant aims at use over 100,000 ft	62D
Intermediate is double-barreled allylic chloride	64A
Lubricant additives up resistance to cold	64B
Spacecraft fuels from pyrophoric B and Al compounds	64C
Monsodium phosphate in new porous form	64D
Steatite ceramic gives small parts dielectric strength	64E
Ashless antioxidant for greases, turbine oils	64F
Sodium lauryl sufate of high purity, low viscosity	64G
Antiozonant-antioxidant now produced in quantity	64H

For more details, use Reader Service Card

99.2% AVAILABILITY

provided by Clark Centrifugal Compressor during two years of glass plant service!

Still in "Like New" condition, a Clark Model 2M7 Centrifugal Compressor recently posted an outstanding service record in a glass plant application by logging a total of 16,968 trouble-free hours. Scheduled downtime for maintenance amounted to only 0.84% of availability despite the fact that the compressor was operated for eight months in an atmosphere charged with silica dust before an air filter was installed. But trouble-free service is only the beginning for this dependable Clark compressor, as indicated by the two-year service report at right. For this kind of quality and dependability, contact your Clark representative or write to:

CLARK BROS. CO.
OLEAN, NEW YORK

CLARK

COMPRESSORS • ENGINES • GAS TURBINES

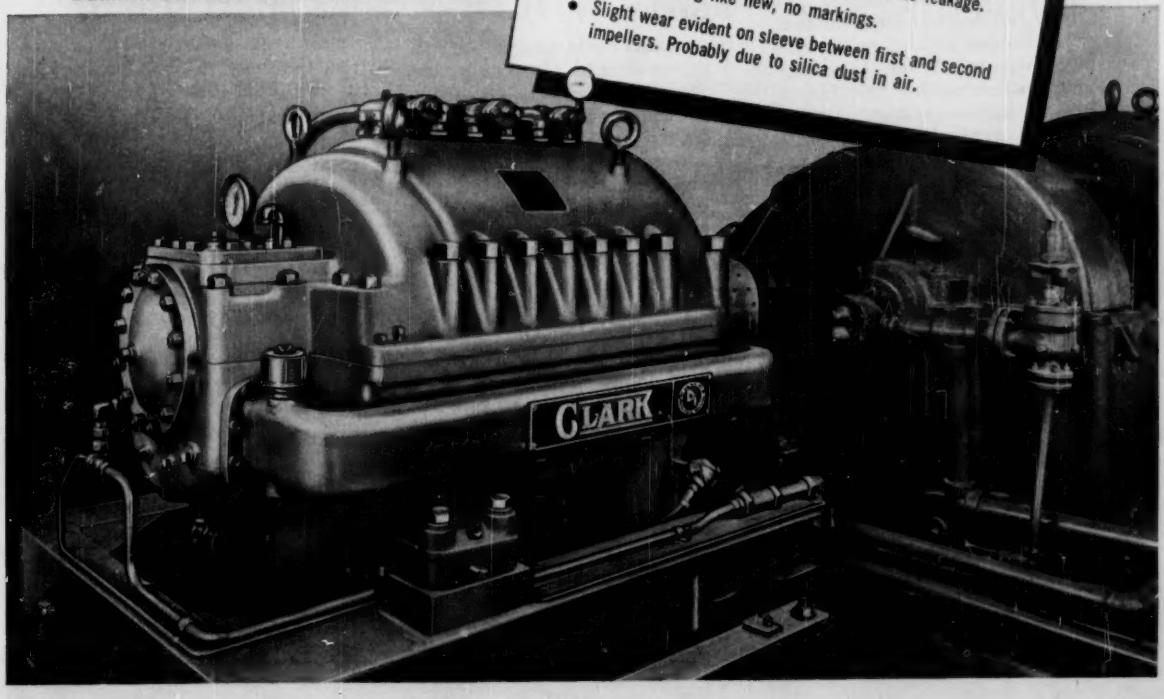
SERVICE REPORT

MODEL—Clark 2M7 Centrifugal Compressor. Horizontally split, down connected, with diaphragm cooling. Rated 1415 bhp. Capacity 7500 cfm. Gear driven by 1200 rpm electric motor.

APPLICATION—Air compressed from 13.36 to 73.36 psia to supply 40% of requirements of nine furnaces producing glass for 1,100,000 bottles daily.

CONDITION OF PARTS—Labyrinths like new, with original knife edge. Clearances well within tolerances.

- Rivets in factory condition, none loose.
- Impeller blades like new, no visible wear on trailing edges.
- Bearings and shaft like new. Slight marks and spots, otherwise polished factory finish.
- Original oil still in machine in clear, clean condition.
- Discharge impeller (seventh stage), no bluing or heat effects evident.
- Discharge seals in excellent condition, no leakage.
- Thrust bearing like new, no markings.
- Slight wear evident on sleeve between first and second impellers. Probably due to silica dust in air.



At this altitude, the use of lubricants containing organic binders results in prohibitive outgassing.

Test results on the product also show longer wear life than organic bonded solid film lubricants, oils or greases. It lubricates in temperatures up to 700 F. in the presence of not more than 1% free oxygen.—**Electrofilm, Inc., North Hollywood, Calif.** 62D

Intermediate

"Double-barreled" allylic chloride has reactive double bond.

Now available is a new intermediate, 1,4-dichloro-2-butene (DCB). It is a clear liquid, and contains an exceptionally high amount of the trans isomer—95 to 98% by weight. This high purity plus its broad range of reactivity makes it suitable for use in a wide variety of syntheses.

Component	% by Wt.
Trans-1,4-dichloro-2-butene	95-98
Cis-1,4-dichloro-2-butene	2-5
3,4-dichloro-1-butene	0.2-0.5
Low boilers	0.02-0.05
High boilers	0.1-0.5

In addition to having a reactive double bond, this compound has two chlorine atoms which undergo reactions typical of allylic halides and in a number of instances allylic rearrangement occurs. When this happens, the remaining chlorine exhibits the lower degree of reactivity typical of non-allylic halides.

DCB reacts with tertiary amines to produce high yields of bisquaternary ammonium compounds. Displacement reactions with organic and inorganic salts occur readily. Potassium thiocyanate gives the corresponding dithiocyanate; silver nitrate gives the dinitrate; and sodium acetate gives the diacetate. Diethers are readily made when the chemical is treated with alcohols in strongly alkaline solution.

Reactions of these types suggest potential markets for 1,4-dichloro-2-butene and its derivatives in the rubber, petroleum, electroplating, pharmaceutical, and textile industries.—**Du Pont Co., Wilmington.** 64A

Lubricants

New additives up resistance to cold.

A new line of lubricating oil additives, the 500 series has been designed to prolong the life of today's high-compression automobile gasoline engines which operate much of the time at low temperatures.

The new additives are balanced blends of dispersants and detergents and have proved effective in checking engine deposits during "cold-engine" operation, typical of "short-trip" or "stop-start" driving.

The new 500 series additives also give excellent results in high-temperature operation — that is when the engine is running at sustained high speeds, as if often the case with diesel engines. In effect, low-temperature detergency has been added to test-proven high-temperature performance of its best diesel and gasoline engine additives. The broad range of products' effectiveness has been substantiated by 250,000 mi. of road testing in taxicabs.—**Oronite Chemical Co., San Francisco.** 64B

BRIEFS

Spacecraft fuels may come from power-packed chemicals that ignite themselves, according to company's H. A. Beatty. These substances offer the prospect of engines smaller and more powerful than any yet developed for aircraft, missiles and space vehicles. High energy and pyrophoric fuels, which contain boron or aluminum, can release energy more rapidly than such conventional hydrocarbon fuels as gasoline, kerosene.—**Ethyl Corp., New York.** 64C

Monosodium phosphate granules in a new porous form combine the desirable qualities of both crystalline granular and powdered MSP. For use in metal cleaning, phosphatizing and dairy cleaning fields, it has the ability to hold up to 10% liquid nonionics without becoming wet looking.—**Monsanto Chemical Co., St. Louis.** 64D

Steatite ceramic called Lavolain has been designed for the production of relatively small parts requiring specific electrical and mechanical properties. It combines high dielectric strength combined with good mechanical strength and thermal shock resistance.—**Star Porcelain Co., Trenton, N. J.** 64E

Ashless antioxidant based on a mixture of aryl amines is now available for use in greases, turbine and crankcase oils, and ester lubricants. Called Ortholeum 302 antioxidant, the compound may be used as a stabilizer in synthetic lubricants to inhibit viscosity change, copper corrosion, and acid number increase in high temperature oxidation tests. —**Du Pont Co., Wilmington, Del.** 64F

Sodium lauryl sulfate of higher purity and lower viscosity than types available in the past has been developed for use in shampoos. Called Duponol QC surface active agent, it differs from the conventional in its very low viscosity and flat temperature-viscosity curve. This makes it easier to handle, particularly in cold weather. —**Du Pont Co., Wilmington, Del.** 64G

Antiozonant-antioxidant, Flexzone 3-C, will be produced in quantity at a plant in Naugatuck, Conn., to be completed late in 1960. Chemically it is N-isopropyl-N'-phenyl-p-phenylene diamine.—**U. S. Rubber Co., New York.** 64H

For More Information . . .

about any item in this department, circle its code number on the

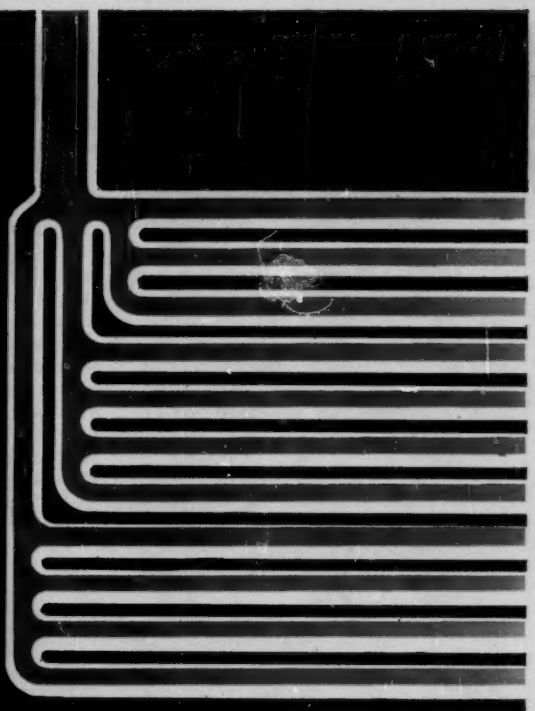
Reader Service

postcard (p 183)

MULTI-ZONE

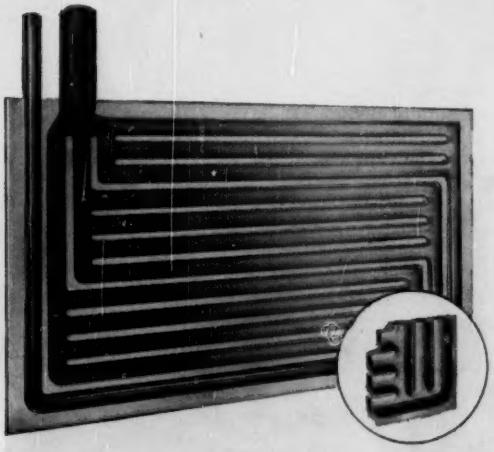
PLATECOIL®

IS AN EXCLUSIVE TRANTER ADVANCEMENT IN HEAT TRANSFER TECHNOLOGY



The new MULTI-ZONE PLATECOIL introduces a new principle of coil design. The multiple header, multiple return pass arrangement produces FREE-FLO action. Steam is distributed to all levels of the coil almost instantaneously. This new design overcomes the problem of condensate "trapping" — a disadvantage of common pipe coils and single-headered units—that robs effective heat transfer area. Only TRANTER PLATECOIL offers the extra capacity of MULTI-ZONE heat distribution.

MULTI-ZONE PERFORMANCE SOLVES TOUGH TANK AND PROCESS HEATING PROBLEMS



Better steam distribution provides a reserve capacity for heat transfer to overcome overload conditions which drop tank and process vessel temperatures. Heat-up time after tank or processing equipment shut-down is cut to a minimum. Tank temperatures are maintained within closer limits and production is improved.

More effective heat transfer area and more heat transfer per square foot of area makes it possible to use fewer and more compact PLATECOIL units than is possible with other types of equipment. Valuable tank space is saved and the need for addition of new tanks to get higher production is often eliminated.

Add to these performance advantages, l w cost of installation and operation, economical maintenance and scientific engineering for the best answer to your heat transfer problems.

Write for NEW Bulletin P61 for complete data.

Tranter Manufacturing, Inc.

LANSING 9, MICHIGAN

PLATECOIL® DIVISION

DEVELOPMENTS . . .

PROCESS EQUIPMENT

EDITED BY C. C. VAN SOYE

Sorptometer

Simplifies measurements of adsorption phenomena.

Manufactured under exclusive license from Shell Development Co., (Emeryville, Calif.), Perkin-Elmer's Model 212 Sorptometer enables simple and accurate studies of surface area and other adsorption phenomena.

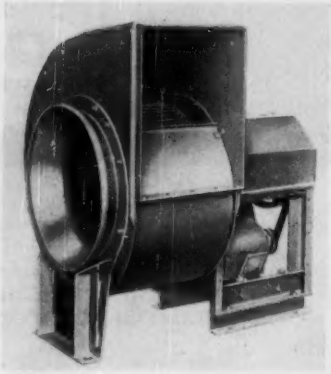
In operation, Model 212 passes a known helium-nitrogen mixture through a sample cooled by liquid nitrogen. Change in the mixture's nitrogen concentration is detected by a thermal conductivity cell, and inscribed as a peak on a potentiometer recorder chart. On warming the sample, measurement of nitrogen released provides a second peak. Areas of the two peaks are proportional to nitrogen adsorbed and desorbed. Simple calculations then afford required data. — **Perkin-Elmer Corp., Norwalk, Conn. 66A**

Electrical Insulation

Gives insulators 300 times more arcing resistance.

A new insulation that can be painted or sprayed on electrical equipment dries to form a smooth and attractive surface having great resistance to breakdown by electrical arcing or "tracking." When applied to existing equipment, the new paint brings to less-modern insulation a better-than-new resistance.

Functional component of the insulation is an epoxy resin. Adhesive properties of this resin are responsible for the insulating properties of the paint.— **Westinghouse Electric Corp., Pittsburgh, Pa. 66B**



Industrial Fans

Two models, of 25 sizes, for gas supply or exhaust.

A new line of V-belt-driven fan sets, furnished complete with motor and drive assembly, are suited to exhaust or supply applications, indoors or outdoors. The manufacturer lists fan ratings as 25,000 cfm. at static pressures through 2½ in. H_2O, and temperatures to about 300 F.

Distinguishing features include: easy accessibility to motor drive and bearings; easy field change of discharge direction; statically and dynamically-balanced wheels; good motor ventilation; and heavy-duty construction throughout.

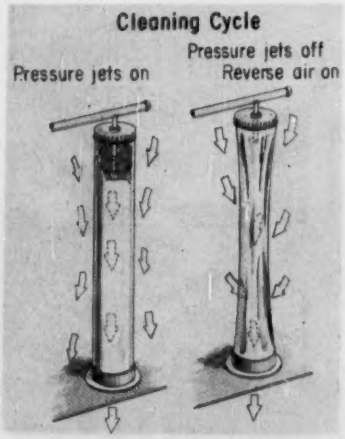
Type LS units have low-speed, forward-curved multiblade wheels, and come in 13 sizes. Type MS has medium-speed, back-inclined wheels, and is offered in 12 sizes.—**Clarage Fan Co., Kalamazoo, Mich. 66C**

Weighing System

Accurately handles pulpy feeds. Electric controls.

Richardson Scale has introduced a new system that evenly and regularly feeds and weighs shredded wood pulp or similar low-density materials. The system handles materials measuring as little as 3 lb./cu. ft., at up to six 10-lb. weighings per min., say company officials.

In the RS system, material moves from a surge bin to a transition hopper via a twin-screw feeder. It then travels to the scale hopper of a Model E-52 net-weighing scale by means of the scale's own screw feeder. Electrical feeder instruments automatically control system functioning and material flow.— **Richardson Scale Co., Clifton, N. J. 66D**



Dust Collector

Air-cleaned unit operates at high temperature.

Developed specifically to solve air pollution problems arising from severe fume and dust emissions, the new Type CO dust collector operates at temperatures as high as 550 F., with glass filter fabrics. The unit

LINDE packaged oxygen plant sets nine-year record for availability!

THE LINDE oxygen plant shown here has been serving a leading chemicals producer "over-the-fence" continuously since 1949. Its operating log shows a 98%+ availability factor. This year, capacity has gone up from 360 to 800 tons of oxygen a day.

You can expect the same continuity of supply with a LINDE packaged plant serving your process. Your LINDE plant will be the product of fifty years' experience in the design, manufacture, and operation of air separation plants and low temperature equipment. LINDE is uniquely qualified to provide air separation plants for the supply of oxygen and/or nitrogen as well as the associated low temperature equipment for:

liquefying hydrogen, helium and fluorine
purifying hydrogen and helium
separating hydrogen from coke oven gas
ammonia and methanol synthesis
upgrading of natural gas
other extremely low temperature processes.

Put LINDE's more than 50 years' experience in gas separation techniques to work for you. Write Dept. CE-102, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

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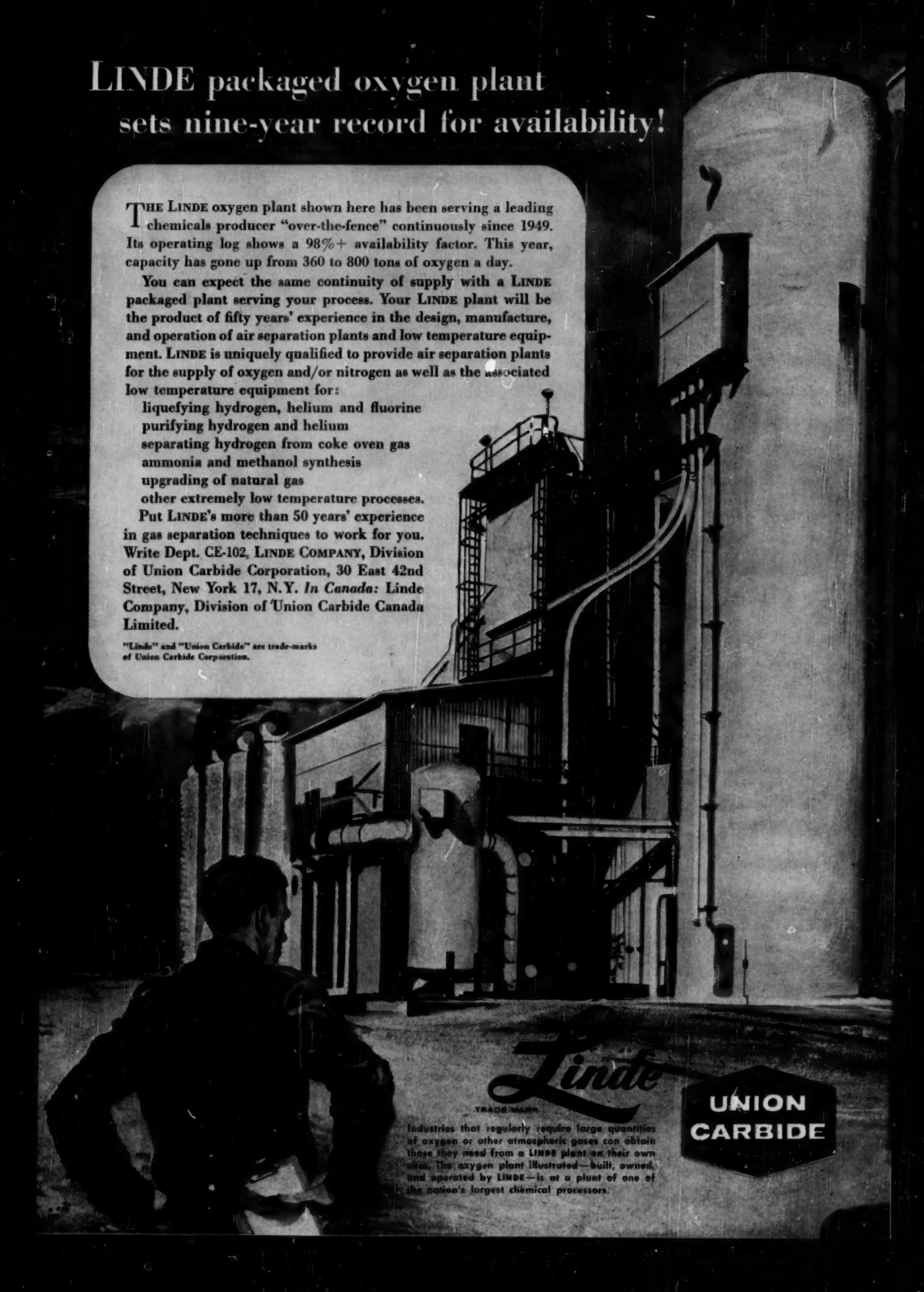


Linde
TRADE MARK

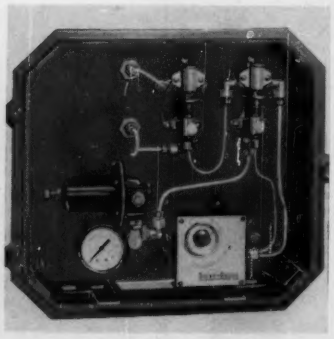
UNION CARBIDE

Industries that regularly require large quantities of oxygen or other atmospheric gases can obtain those they need from a LINDE plant on their own sites. The oxygen plant illustrated—built, owned, and operated by LINDE—is at a plant of one of the nation's largest chemical processors.

will perform equally well with any filter fabric at lower temperatures.

In operation, dust collects on the inside surfaces of the filter tubes. Cleaning, via the Pressure-Jet method, functions by blasting collected dust with short spurts of high-pressure air, alternating with a small amount of reverse airflow from the main fan. This partially collapses tubes, cleans filter surfaces and deposits residue into storage hoppers for easy disposal.

Intensity of cleaning action regulates from a slight pulsation to the equivalent of mechanical shaking. Since there are no internal moving parts, stress on casing, structural members is minimal. — **Pangborn Corp., Hagerstown, Md. 66E**

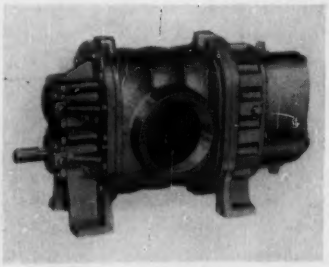


Pneumatic Timer

Sends out timed pressure signal of preset amplitude.

Servo-Gauge Oscillator, a pneumatically actuated timer having no moving parts, emits a repetitive pneumatic signal impulse of preset magnitude, or of various magnitudes if initiated by controller. Signaling impulse frequency, variable from 0.3 to 60 cycles/min., adjusts from within the instrument case. Amplitude of the rectangular pressure-wave output is 0 to 30 psig.

According to the manufacturer, the instrument is ideal for explosion hazard areas, remote field locations and for any service demanding repeated accuracy of response. Typical applications include speed control of diaphragms, on-off control of cylinder-operated valves, etc.—**Associated Control Equipment, Inc., Coraopolis, Pa. 68A**

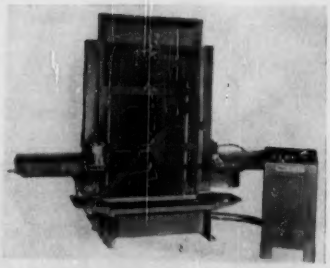


Vacuum Blowers

Low operating costs for low-volume service.

A new line of small-volume vacuum blowers is offered with capacities from 30 to 1,000 cfm., and vacuums to 20 in. Hg in single-stage application. For vacuum service over 20 in. Hg, the units may be compounded.

Major design features include elimination of internal valves, absence of contact between moving parts, low maintenance and minimum sealing-water requirements. At reduced vacuums, the units will operate without sealing water for certain applications.—**Roots-Connersville Blower, Connersville, Ind. 68B**



Tube-Bundle Cutter

Automatic machine reduces maintenance costs.

Designed to cut heat-exchanger tube bundles close to the tube sheet, Model 12-20G band saw is claimed by the manufacturer to be safer and faster than many other cutting methods now in use. Operation is automatic.

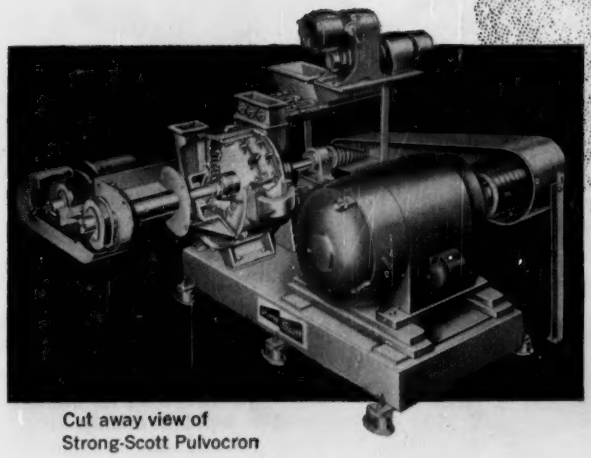
Standard electrical equipment provides for 110-v. control circuits, oil-tight pushbutton stations, high-limit safety switch and blade-pressure controls. Standard models will cut 48- or 60-in.-dia. tube bundles. When necessary, basic design can be modified to meet individual job requirements. — **Wells Mfg. Corp., Three Rivers, Mich. 68C**

Safety Relief Valve

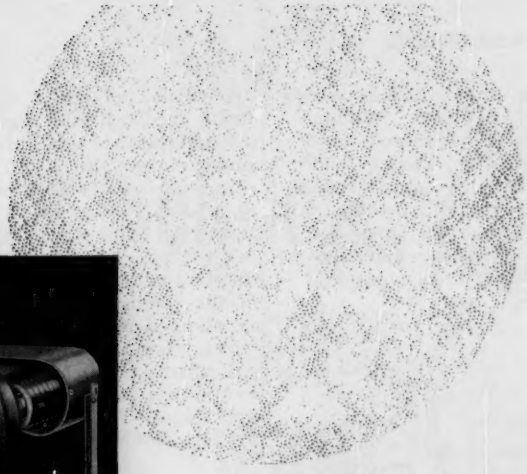
Resists corrosives, other than HF, hot caustics.

Constructed of Pyrex-brand glass and Teflon resin, a new series of safety relief valves for pressure, vacuum and combination service features complete visibility and exceptional corrosion resistance. Topworks and spring components are completely sealed from fluids handled.

Valves of the "500" Series come with a patented seat which is claimed to be a new construction concept. Seal between seat and plunger remains constant



Cut away view of
Strong-Scott Pulvocron



Magnified Sample of
SITOSTEROLS
Pulverized to
minus 10 microns

Pulverizing with Selective Particle Size Control!

INCREASE PRODUCTION AND CUT OPERATING COSTS WITH THE NEW PULVOCRON

Because this unit is so versatile, it can pulverize hard or soft materials and can operate in the extreme fineness range (95 to 99% finer than 5 to 10 microns) or it can operate in the coarse particle size range (50 mesh and thereabouts).

The Pulvocron is now being used to solve many size reduction problems in the chemical, food and related process industries. Available in 20 and 38-inch grinding chambers and constructed of carbon or stainless steel.

SPECIAL FEATURES

- **Pulverized product particle size control**
- **Pulverized product temperature control**
- **Installation versatility**
- **Accessibility for inspection**
- **Sturdy construction for years of service**

THE PULVOCRON IS AN ADVANCED IMPACT AND AIR ATTRITION PULVERIZER COMBINED WITH INTERNAL PARTICLE SIZE CLASSIFIER.

TYPICAL INSTALLATIONS USING 20" PULVOCRON

Product	Soya Sitosterols
Feed Material .	40 Mesh (Approx.)
Pulverized . . .	99.99% minus 10 microns
Capacity	500 lbs. per hr.

Product	Urea Formaldehyde
Feed Material .	¼ to ⅝" Diameter
Pulverized . . .	99% minus 80 Mesh
Capacity	1600 lbs. per hr.

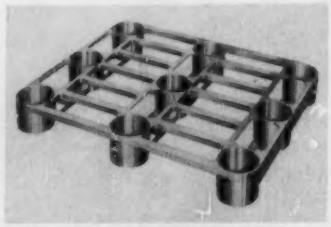
Consult Strong-Scott with your pulverizing problems

The **Strong Scott** Mfg. Co.

451 Taft Street N. E., Minneapolis 13, Minnesota • Phone: STerling 1-7461

EQUIPMENT DESIGNED FOR BETTER PROCESSING

as sealing pressure increases with inlet pressure buildup. Seat pressure never goes into balance with the spring load. After operation, the valve reseats without costly rupture-disk replacement. Operating range is 5 to 35 psi.—**Chemflow Corp., Lodi, N. J.** **68D**

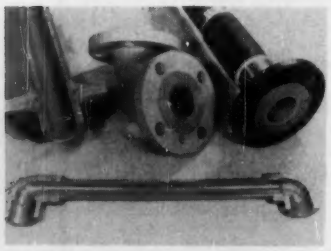


Magnesium Pallet

Consistent weight and size; 4-way entry.

According to Mag-Craft Corp., its new magnesium material-handling pallet offers numerous advantages over the wooden counterpart. It is lighter in weight, has increased load capacities in addition to extreme handling ease. Elimination of fasteners and high-mortality materials eliminates pallet maintenance problems.

Now available in a wide variety of sizes to meet most needs, the pallets are also offered with aluminum construction.—**Mag-Craft Corp., Grand Rapids, Mich.** **70A**

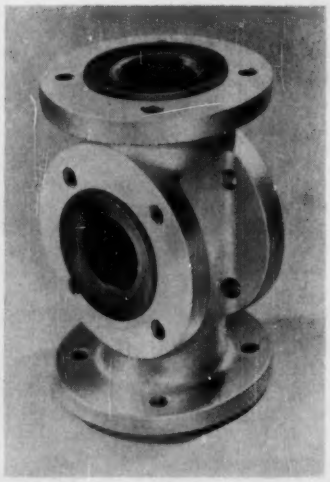


Thermoplastic Fittings

To handle solvents and hot corrosive fluids.

Penton-lined metal fittings and pipe, and all-Penton fittings are now available in a wide range of sizes. Penton is a chlorinated polyether thermoplastic credited with high corrosion resistance and ability to handle elevated temperatures.

Initial production plans call for all-Penton fittings in sizes from ½ to 2 in. threaded and socket type, Schedule 80. Carbon steel or aluminum pipe and fittings lined with the plastic are planned in ½- to 3-in. sizes. Prices, says the manufacturer, will run as much as 50% less than those for fluorocarbon-lined pipe.—**Tube Turns Plastics Inc., Louisville, Ky.** **70B**

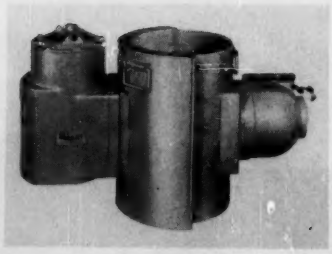


Saw Cross Fittings

Have linings of corrosion-resistant resin.

Chemically inert crosses lined with Fluoroflex-T are now available as standard fittings in the manufacturer's line of process equipment. The liner extends over the full gasket face of all four flanges to provide a uniform, continuous barrier against corrosive fluids. Balanced rates of thermal expansion-contraction, maintained between the 150-lb. ductile iron housing and the liner, free the fittings from effects of thermal shock and fatigue stress.

Type S crosses, now available in 1- to 6-in sizes, will be supplemented in the near future with an 8-in. size. Flange dimensions in bolt circles of all fittings are ASA.—**Resistoflex Corp., Roseland, N. J.** **70C**



Density Gages

Detected radiation proportional to S.G., % solids.

Two new gages, Model NLRV and Model LR, apply gamma radiation to the continuous, automatic and accurate measurement of specific gravity, percent solids or interface passage in piping 10 through 16 in. dia. Both models build into lines or bolt around the outside of existing piping. Gage parts do not touch fluids being measured; there are no moving parts.

Heavy shielding of the radioactive gamma source permits general license distribution to companies with no prior radioisotope experience. Explosion-proof design is standard.

Minimum measurement span for 16-in. line is 0.05 S.G.; precisions run as high as 1% of scale.—**The Ohmart Corp., Cincinnati, Ohio.** **70D**

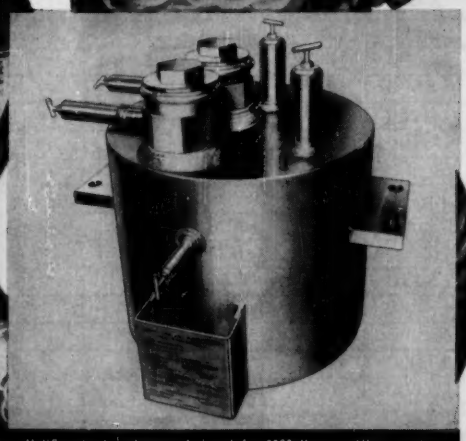
Overseas Developments

New flame ionization detector; new precipitator.

From "Down Under" comes news of a new device that analyzes the composition of gases with high sensitivity and speed. Developed by Imperial Chemical Industries of Australia and New Zealand, Ltd., (Melbourne), the unit will identify and record impurities as small as 1×10^{-12}g. Originally designed to analyze ethylene gas, from which ICI makes polyeth-

EQUIPMENT NEWS
Continues on . . . Page 165

Heliflow® goes to sea with Triton



Heliflow heat exchanger designed for 2500 lbs. operating pressure on both shell and tube sides. All stainless 304 material.

—and proudly so! In the instance of the Triton, Heliflow was selected by one of the most outstanding engineering organizations in the world—the **Knolls Atomic Power Laboratory** operated by the **General Electric Company.**

The requirements for the Triton job were most exacting—and Heliflow came through with flying colors.

Heliflow goes to sea with Triton to do another of the many vital and important jobs it has done for Uncle Sam during the past several decades both in war and peace. Whenever a really compact, efficient and dependable heat exchanger is required—to accurately do a tough job—Heliflow is the choice of capable engineers.

If Heliflow can do THIS job, don't you agree that it can do yours?

Ask for Bulletin 58E. It tells you why.

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Offices in principal cities and Canada

Factory: Batavia, N.Y. Other Graham precision-built products: Steam Jet Ejectors, Monobolt Heat Exchangers, Deaerating Heaters, Surface and Barometric Condensers, Steam Vacuum Refrigeration, Aquamizer Evaporative Condensers.

1959 TOWER TESTS

Show Marley's Plus Performance Value

Here is the RECORD OF PERFORMANCE . . . consecutive results of all acceptance tests of Marley industrial Cross-Flow cooling towers made in 1959. This tabulation certifies Marley's ability to rate towers correctly and its single-minded purpose of applying them exactly as rated. Here are factual reports from 27 Marley installations in all parts of the country. Their specified capacities, operating conditions and types of service are as diversified as their geography, but tests uniformly emphasize the fact that these customers received a performance bonus that points up Marley Cross-Flows as vital investments in plant capacity and operating efficiency.

TEST NO.	TYPE OF SERVICE AND LOCATION	SPECIFIED CONDITIONS				TEST RESULT[4]	
		Gallons Per Minute	Hot Water Temp.	Cold Water Temp.	Wet Bulb Temp.	Degrees Cold Water Temp.[5]	Percent Capacity
1[1]	Generating Station—Mid-Atlantic	220,000	97°	78°	70°	+0.35°	+ 3.5%
2	Petroleum Refinery—Gulf Coast	3,500	95°	83°	70°	+ .47°	+ 4.0%
3	Generating Station—Southern	20,000	100°	85°	78°	+ .19°	+ 1.9%
4	Generating Station—Rocky Mtns.	89,300	95°	82°	60°	+1.88°	+ 9.75%
5[2]	Generating Station—S. Atlantic	75,000	113°	90°	74°	+ .20°	+ 1.25%
6	Petroleum Refinery—Gulf Coast	8,600	105.8°	87°	82°	+ .45°	+ 5.8%
7	Appliance Mfg. Plant—E. Central	7,750	95°	85°	78°	+ .40°	+ 5.00%
8[2]	Petroleum Refinery—Gulf Coast	45,000	112°	89°	82.5°	+ .72°	+ 6.65%
9	Generating Station—Mid-Central	62,400	107.5°	90°	76°	+1.10°	+ 7.3%
10	Petroleum Refinery—N. Atlantic	12,900	115°	85°	78°	±0.00°	± 0.0%
11[2]	Meat Packing Plant—North Central	6,000	105°	85°	75°	+ .60°	+ 5.2%
12	Jet Engine Plant—South Atlantic	20,000	95°	85°	79°	+ .40°	+ 6.0%
13	Generating Station—Gulf Coast	65,000	104.6°	87°	76.5°	+ .45°	+ 3.3%
14[2]	Petroleum Refinery—Gulf Coast	17,500	111°	90°	80°	+ .47°	+ 3.5%
15[2]	Petroleum Refinery—North Central	4,150	110°	75°	68°	— .10°	— 0.6%
16	Petroleum Refinery—East Central	19,400	120°	85°	75°	+ .65°	+ 5.5%
17[2]	Petroleum Refinery—Gulf Coast	57,500	120°	85°	79°	— .17°	— 1.3%
18	Petrochemical Plant—Gulf Coast	15,000	115°	90°	78°	+ .70°	+ 5.3%
19[2]	Air Conditioning—Mid-Atlantic	3,600	95°	85°	78°	+ .70°	+12.6%
20[2]	Atomic Test Facility—North West	70,000	112°	87°	65°	+1.50°	+ 5.9%
21	Chemical Plant—Gulf Coast	1,350	155°	86°	81°	+ .10°	+ 1.4%
22	Air Conditioning—Gulf Coast	7,000	93.5°	86°	80°	+ .30°	+ 6.0%
23[3]	Petroleum Refinery—Central	60,000	120°	80.6°	70°	+ .25°	+ 1.84%
24	Paper Mill—South Central	10,000	116°	86°	79°	+ .05°	+ 0.25%
25	Air Conditioning—South Central	6,000	105°	85°	78°	+ .25°	+ 2.7%
26	Generating Station—Mid-South	38,000	103.2°	90°	80°	+ .70°	+ 5.4%
27	Generating Station—West Coast	34,000	96°	80°	70°	+ .42°	+ 3.75%

NOTES: 1) Total capacity four identical towers: results are average of tests conducted on two towers. 2) Cooling Tower Institute observer present during tests. 3) Test of tower remodeled to increase performance after more than 13 years of service. 4) Test results are adjusted to specified conditions. 5) + indicates lower cold water temperature than specified; — indicates higher cold water temperature than specified.

"TEST YOUR TOWER"—a brochure that details the Marley method of tower testing, and "ANALYZE YOUR BIDS"—one that presents a logical means of pre-purchase evaluation, should be in every engineering library. Your Marley engineer will gladly furnish copies or just send a request to

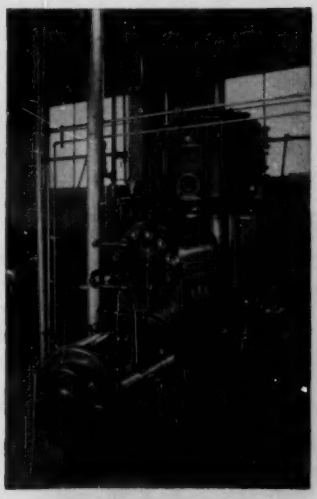
THE MARLEY COMPANY MARLEY **KANSAS CITY, MISSOURI**

60,000 HOURS . . . WITH NO BEARING WEAR

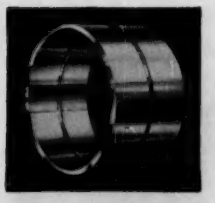
in this IR compressor

Sound unbelievable? Here's how it happened.

This 125-hp Ingersoll-Rand XLE compressor was installed in 1950 at the Standard Products Company in Cleveland. By the summer of 1958 the unit had totalled approximately 60,000 hours of operation, averaging 20 hours a day, six days per week. It was shut down for complete annual inspection as part of the plant preventive maintenance program.



Long before the unit was shut down the customer had ordered new main bearings to keep in reserve stock in event of emergency. It was decided to install the new bearings while the compressor was torn down for inspection. When the old bearings were removed they were checked for wear and were found to be within the original one-thousandth-inch tolerance *for new bearings*. This means that there was *no measurable wear*, even after the equivalent of 20 years of "normal" operation!



Of course, these are not ordinary bearings. They are *aluminum full-floating* bearings, one of the extra-value features found only in Ingersoll-Rand compressors. These heavy-duty bearings roll with the punch of each compressor stroke, distributing the load evenly all around the inside and outside of the shell. Their special aluminum alloy has better load-carrying capacity and higher heat conductivity than other bearing materials. And they *never need adjustment*, so the running gear may be kept sealed from dust and dirt.

Ingersoll-Rand compressors have many more extra-quality features that can save you money in your plant. Call your I-R representative—he has the solution for any compression problem.

The World's Most Comprehensive Compressor Experience . . . **Ingersoll-Rand**

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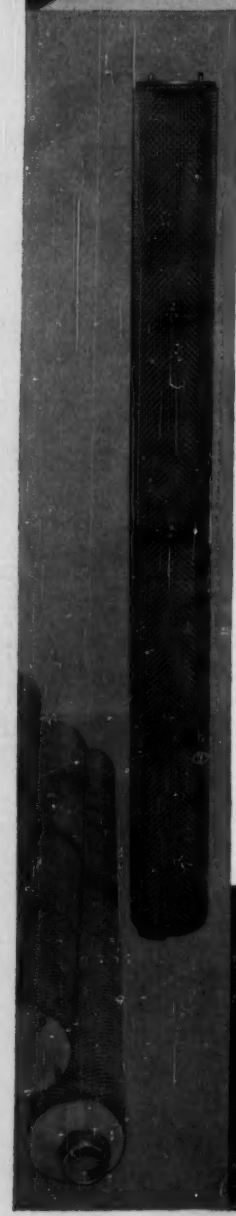
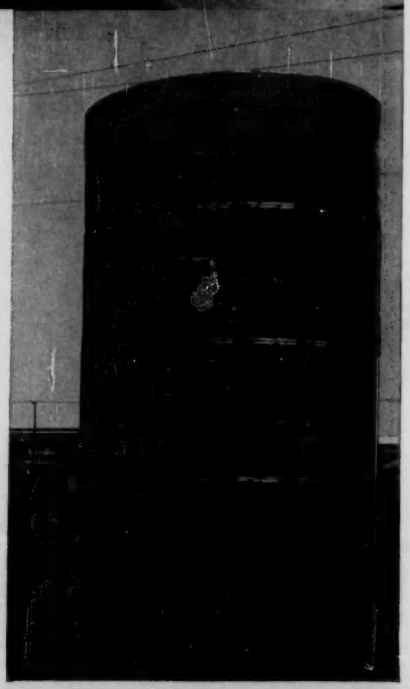
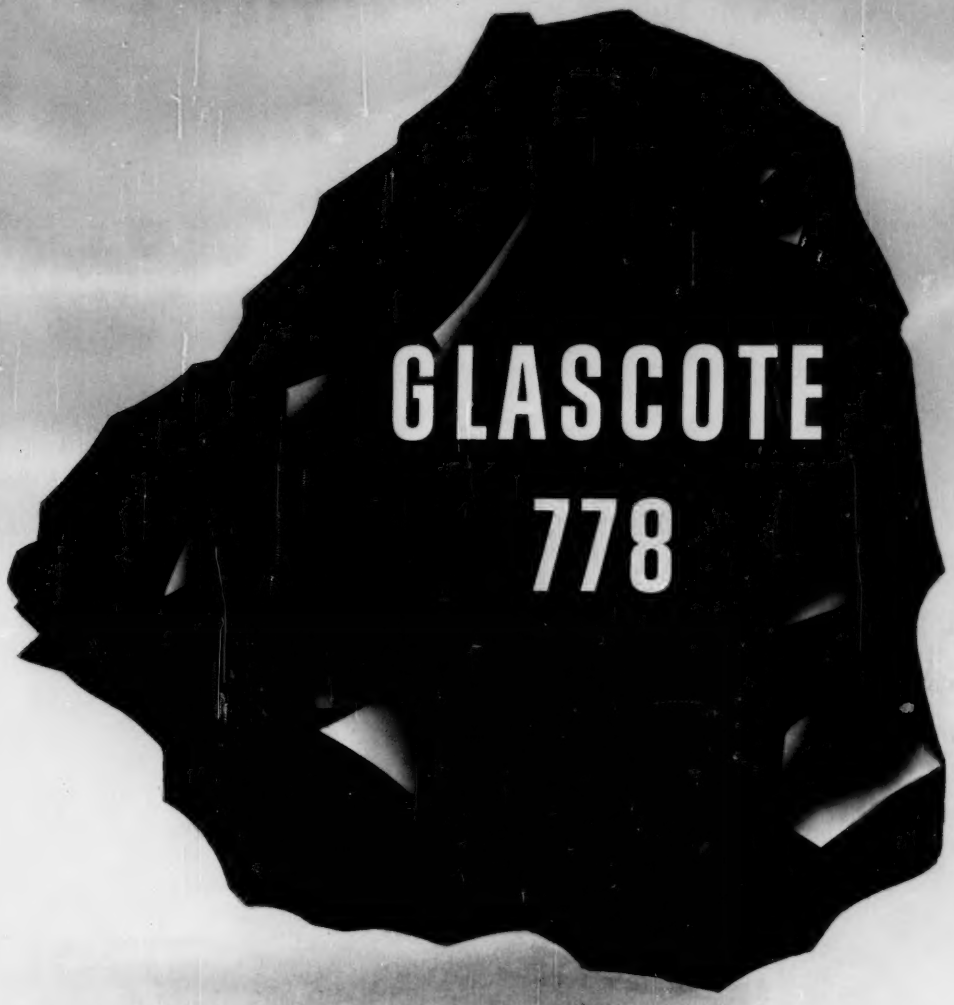
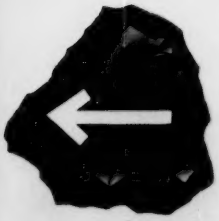




pièce de résistance





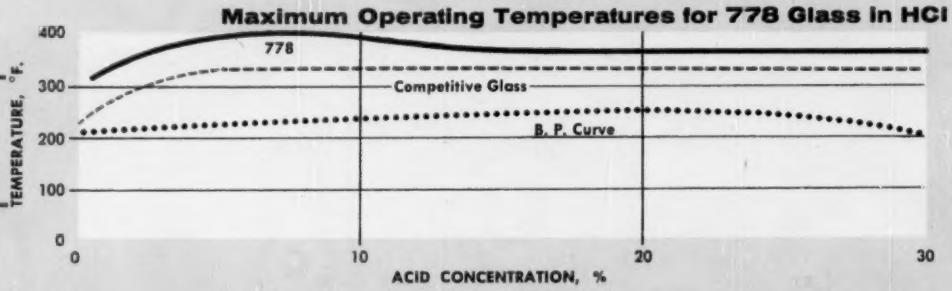
This piece of new Glascote 778 frit is
the most corrosion-resistant glass ever applied
to chemical processing equipment.

Now! Unmatched **Glascote.** 778

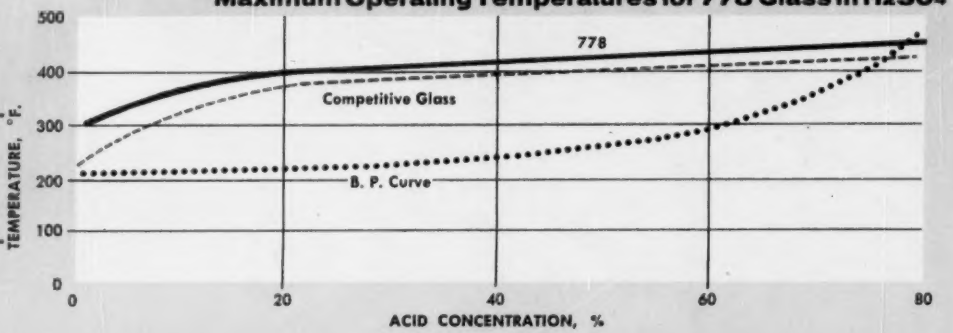
More acid-resistant at up to **75° F** higher operating temperatures

Here's graphic proof that you can speed up reaction time in vessels lined with Glascote 778. The data shown in these charts is substantiated by testing methods presented by D. K. Hoganson at the 1959 annual convention of the American Ceramic Society. We would be happy to send you more complete details on this testing procedure. Drop us a line and your request will receive prompt attention.

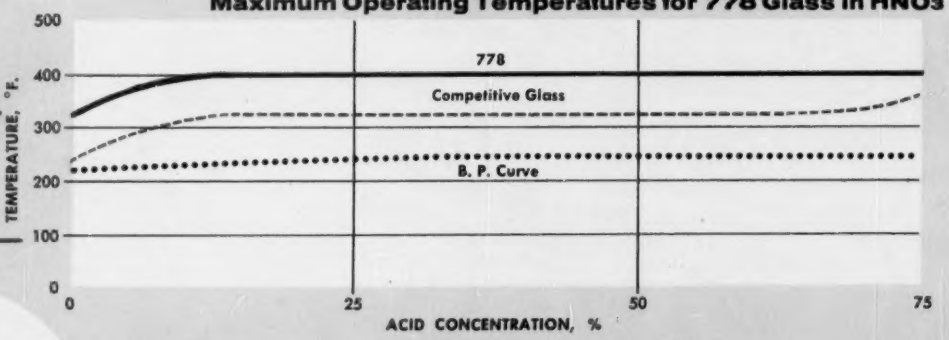
Maximum Operating Temperatures for 778 Glass in HCl



Maximum Operating Temperatures for 778 Glass in H_2SO_4



Maximum Operating Temperatures for 778 Glass in HNO_3

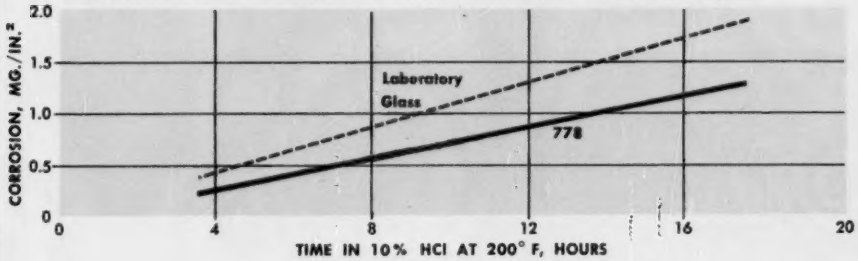


glass-lined chemical processing equipment

More corrosion and thermal shock resistant than chemical laboratory glass

MORE ACID-RESISTANT Ever think you'd see the day when glass-lined steel possessed the acid-resistance of boro-silicate type lab glass? Glascote put new 778 and lab glass to rigid quantitative acid tests — the results proved Glascote 778 not only equal but *superior* to lab glass in its ability to withstand acid corrosion.

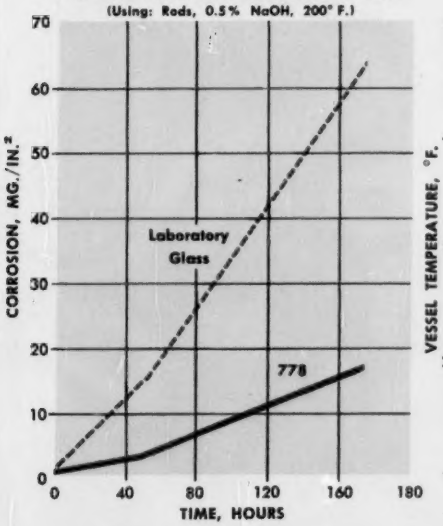
COMPARISON OF ACID CORROSION OF 778 AND CHEMICAL LABORATORY GLASS



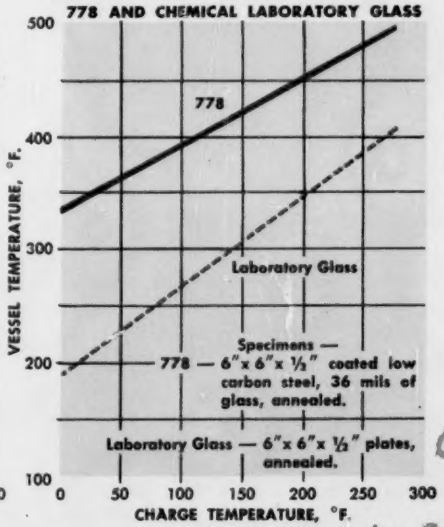
MORE ALKALI-RESISTANT Glascote 778's superior acid resistance was achieved without sacrificing any other protective property. Actually, as an alkali-resistant glass, its superiority over boro-silicate type laboratory glass is even more dramatic.

MORE THERMAL SHOCK-RESISTANT We gave Glascote 778 and untempered boro-silicate type laboratory glass shock treatment too! Heating and quenching tests show Glascote 778 able to resist thermal shock at higher temperatures. However, for applications requiring *even higher* resistance to thermal shock, we've formulated Glascote 558 — a special anti-thermal shock glass.

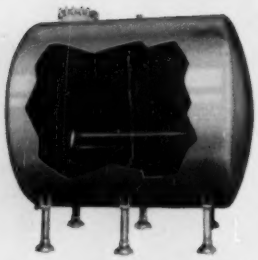
COMPARISON OF ALKALI CORROSION OF 778 AND CHEMICAL LABORATORY GLASS
(Using: Rods, 0.5% NaOH, 200° F.)



COMPARISON OF THERMAL SHOCK LIMITS OF 778 AND CHEMICAL LABORATORY GLASS



For more information on Glascote's equipment line, please turn page



GLASS-LINED STORAGE TANKS — Single shell horizontal types and vertical units available. Plain, jacketed, open and closed. Built to your specifications.

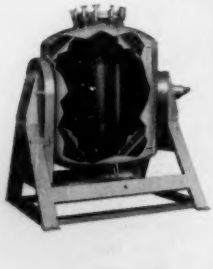
GLASS-LINED HEAT EXCHANGER TUBES — Easily assembled into corrosion-resistant heat exchangers. Standard diameter jacketed pipe, combines with elbows or return bends.

GLASS-LINED PIPE AND FITTINGS — Available in 10-ft. lengths, fittings to ASME standards, in inside diameters from 1½ to 4 in. Six and eight inch and larger sizes to order.

THESE GLASS-LINED PRODUCTS FOR THE CHEMICAL PROCESSING INDUSTRIES ARE ALL AVAILABLE WITH

GLASS-LINED REACTORS — Custom-built up to 8,000 gallons. Standard units from stock range from 300- to 2000-gallon capacities. Feature rotary mechanical seal eliminating contamination from packed stuffing boxes . . . removable blade glass-coated agitators.

GLASS-LINED COLUMNS — Standard and special packed units in glass-on-steel or alloy metals. Built to your specifications in dia. up to 60 in.



GLASS-LINED CONICAL, ROTARY DRYER-BLENDERS — Capacities 5, 35 and 110 cu. ft. as standard, and larger on request. Pressures: tank full vacuum to 25 psi, jacket 65-75 psi.

Glascote 778

Glascote offers you reactors (including high pressure spherical production-size types), columns, storage tanks, rotary dryer-blenders, pipe and fittings — all available glass-lined with Glascote 778 for the best protection ever put to steel.

Glascote 778 is the newest addition to an inventory of more than 3,000 glass formulas developed by Glascote and its parent organization, A. O. Smith Corporation. For example, on those specific applications where a producer has a consistent thermal shock problem, Glascote 558 was formulated to give no-spall performance over an indefinite period of time. And this same Glascote 558 is also industry's most abrasion- and mechanical impact-resistant glass.

The equipment shown on this page is typical of many products supplied for laboratory, pilot plant and full scale commercial production, engineered and fabricated to your exacting specifications.

Ask the representative who calls on you for all the facts on Glascote products. Or if you prefer, write direct: Glascote Products, Inc., Cleveland 17, Ohio.

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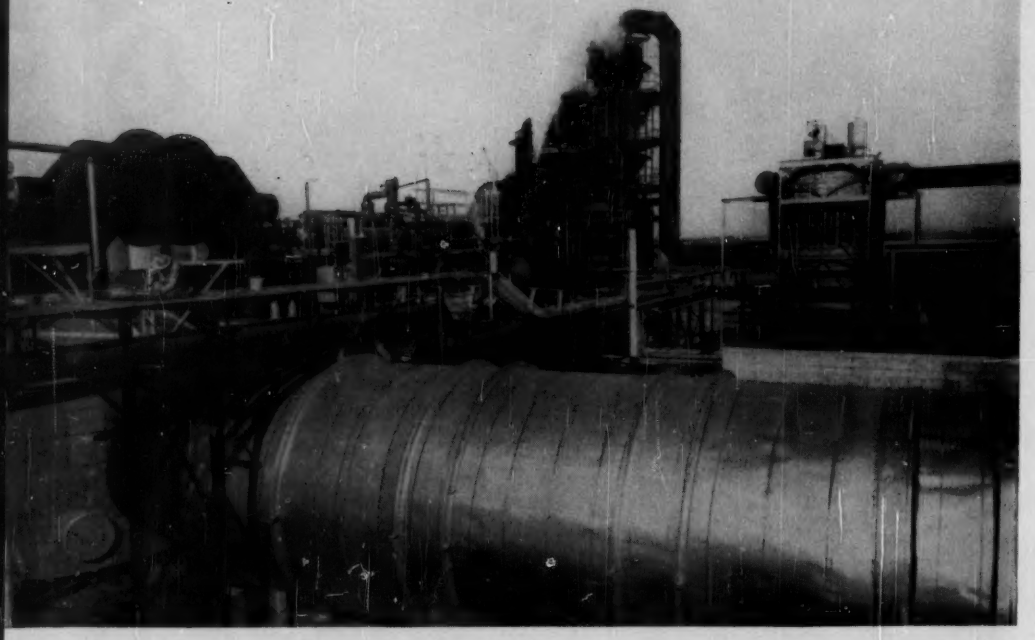
DEVELOPMENTS . . .

PROCESS FLOWSHEET

R. A. LABINE



Unfold Flowsheet

Huge combustion furnace is heart of process for . . .

Converting Waste Sludge Acid to H_2SO_4

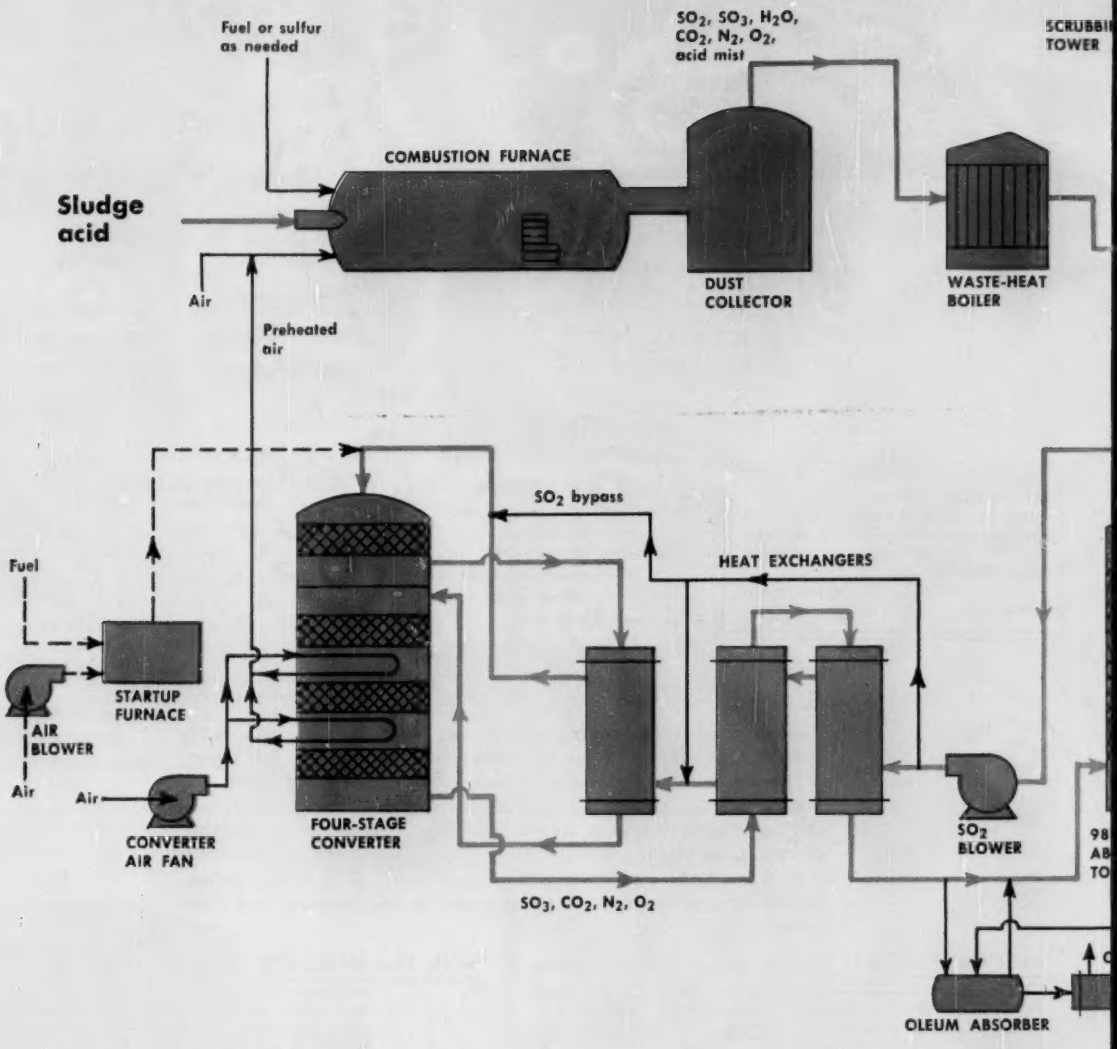
Now on stream in the heart of the nation's largest sulfuric-acid-consuming area is a brand new sludge acid recovery plant owned by Dixon Chemical at Paulsboro, N. J. Built at a cost of more than $5 million, the 715-tons/day plant was designed and erected by Chemical Construction Corp. Using Chemico's own process, plant will process acid sludges obtained from oil refineries spread from the Delaware Valley to southern New England.

Dixon's plant is believed to be the largest single sulfuric acid producing unit in the world. Although based on its relatively standard flowsheet, Chemico has inserted some novel twists in the process to fit Dixon's particular needs.

Briefly, the process consists of burning the acid sludges along with additional sulfur, and fuel if needed, to produce SO_2. This gas stream is then purified to remove acid mist, SO_3 and water, then passes to a conventional sulfuric acid unit.

▶ **Flexibility Is the Word**—Although the nominal design capacity of the plant is 715 tons/day of 98% acid, the plant is able to operate at as low as 25% of capacity or as high as 120% of rated capacity. In addition, acid feedstock varies widely: analysis runs from 90% acid, 4% water and 6% hydrocarbons to only 75% acid, 4% water and 21% hydrocarbons.

The low-acid sludges with high hydrocarbon content are almost heat-sufficient for the burner reaction, but in order to maintain the proper furnace temperature with high-acid sludges some fuel oil or sulfur must be burned along with the feed. Over-all acid recovery from the sludge aver-



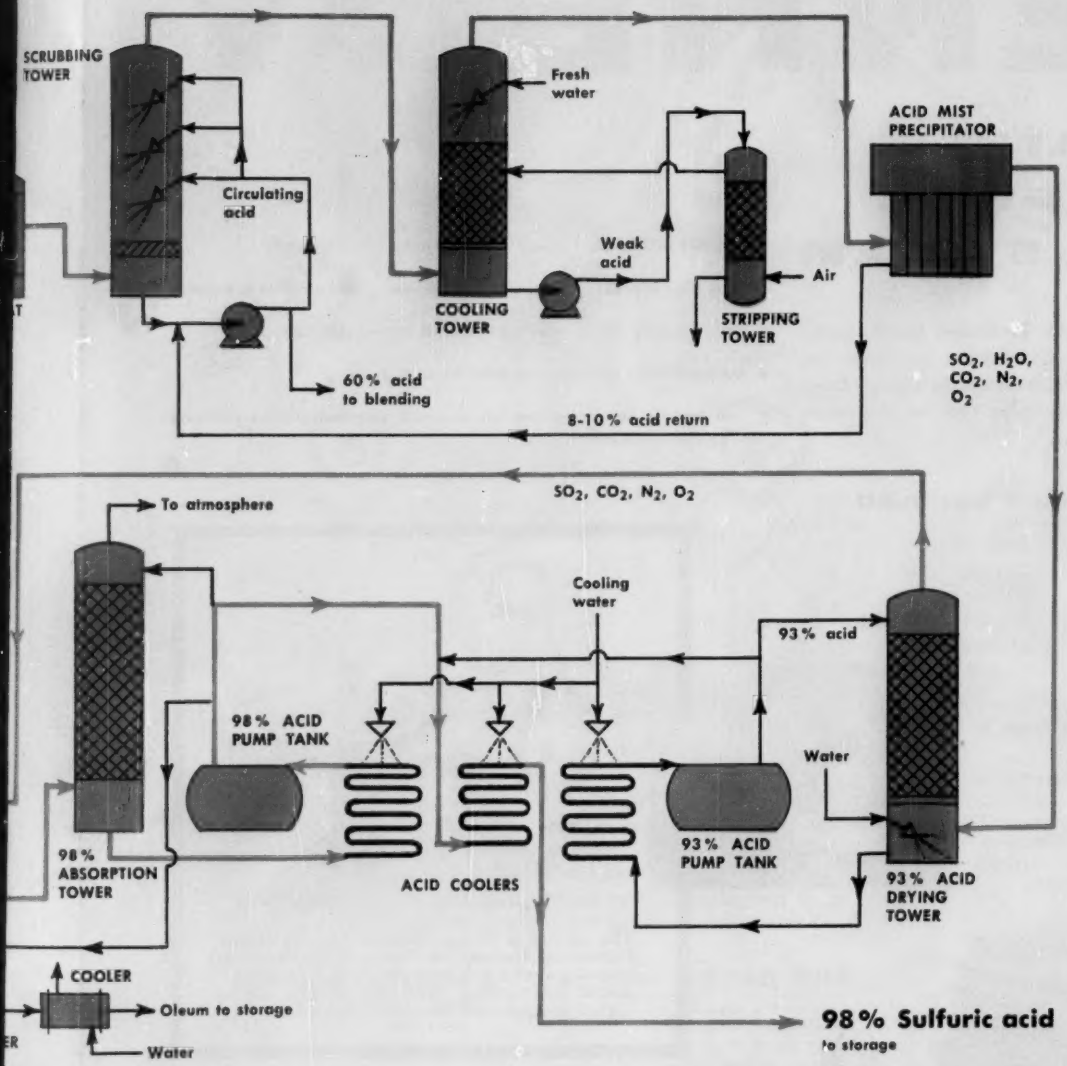
ages 95%; Dixon also burns liquid sulfur along with the sludge acid to provide additional acid production as required.

▸ **Furnace Operation**—Acid sludge is injected into the 16-ft.-dia. burning chamber through a spinning-cup burner. Reaction temperature varies from 2,000-2,300 F. depending on hydrocarbon content of the feed. For minimum SO_3 formation, excess oxygen content must be limited to 2-4% by carefully regulating the amount of air admitted to the burner.

Flame products from the burner pass into a dust collecting chamber where some of the larger ash particles drop out. Gas then passes to a water-tube, waste-heat boiler where gas temperature drops to about 700 F.; care must be taken to stay above the dew point of the acid mist, about 400 F. Ash tends to coat the boiler tubes and they must be steam-cleaned periodically when a rise in exit gas temperature indicates heavy fouling.

▸ **Scrub and Cool**—Gas from the waste-heat boiler flows to a scrubber where SO_3 and acid mist is absorbed in circulating 60% acid. Contacting cool water in a second tower chills the gas stream to 105 F. Passage through an electrostatic precipitator operating at 80,000 v. removes remaining acid mist which is recycled to the scrubbing tower.

Vapor entering the drying tower at 105 F. is now free of all SO_3 and acid mist; contacting with 93% H_2SO_4 in the tower removes all water vapor. Gas then is pulled through a 56,000-scfm. centrifugal blower with a 4 psig. pressure rise. Up to this point the gas stream has been drawn through the system by blower suction because a blower farther



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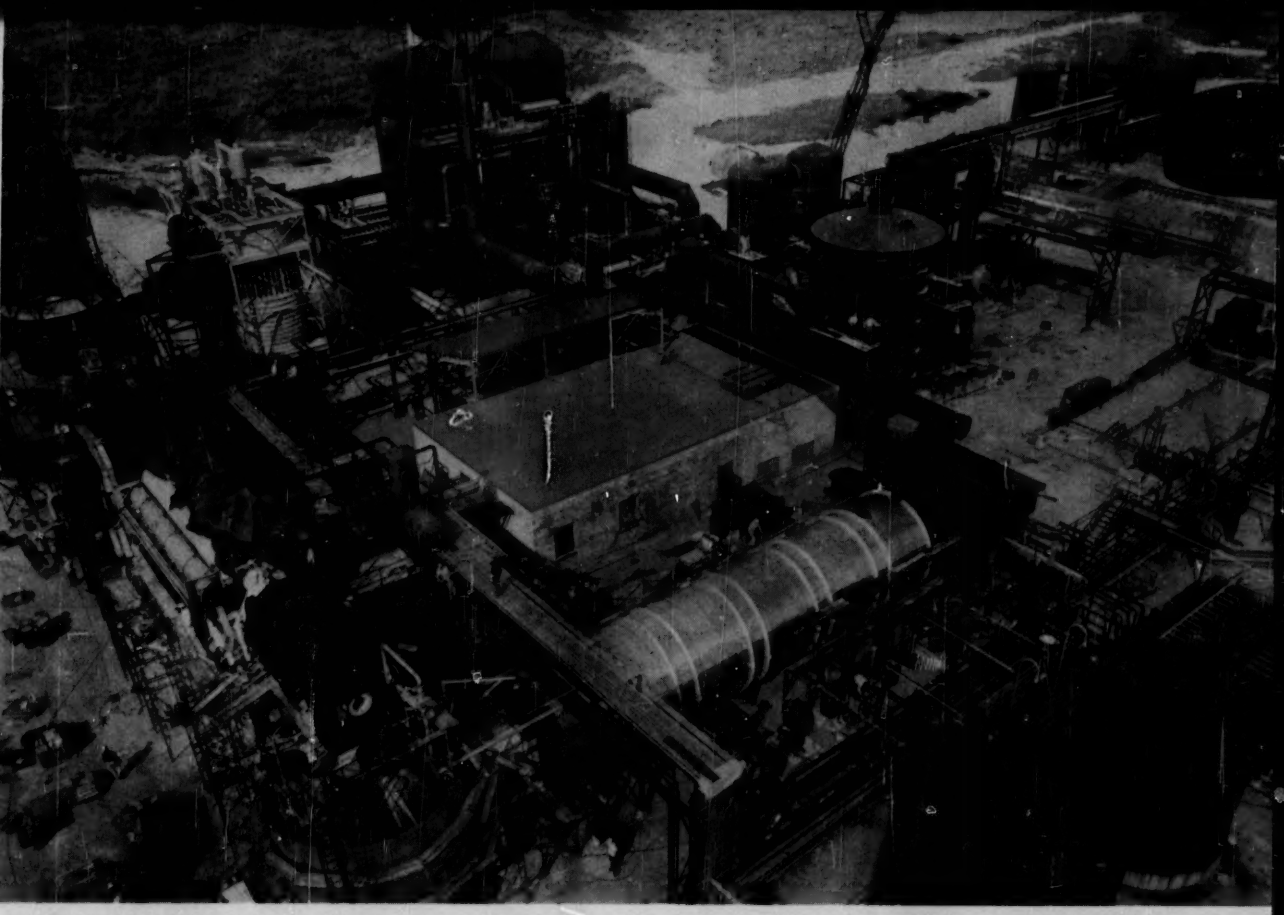
▸ **Preheat and React**—Dry SO_2 gas passes through three shell-and-tube heat exchangers where it is preheated against the hot SO_3 stream leaving the converter. In the Dixon plant, Chemico had to specify extra heat transfer surface for these exchangers and insulate them heavily to insure that at low flow rates the incoming SO_2 gas gets enough preheat. It is also possible to install a small furnace and an additional heat exchanger at this point to supply the needed heat at low flows.

The SO_2 stream enters the converter (28 ft. dia.) at about 820 F. Passing through the first layer of vanadium catalyst, gas temperature rises to about 1,100 F. after about 75% of the SO_2 is converted to SO_3. Gas stream cools back to 830 F. against the incoming SO_2; heat of reaction in the next two catalyst beds is removed by cold air circulating through hairpin coolers. Exit SO_3 stream from the converter is at about 825 F. before passing through the exchangers.

▸ **Absorb and Blend**—Cool SO_3 stream enters the absorption tower at 325-375 F. where it contacts 98% acid. Theoretically, the amount of water required for the absorption reaction is available from the gas stream in the drying tower. In practice, however, small amounts of water are added through a spray in the bottom of the 93% acid tower to allow greater plant operating flexibility. Product acid from the absorber is cooled and sent to storage tanks.

Dixon makes several other products besides the 98% acid. A 60% acid stream is drawn from

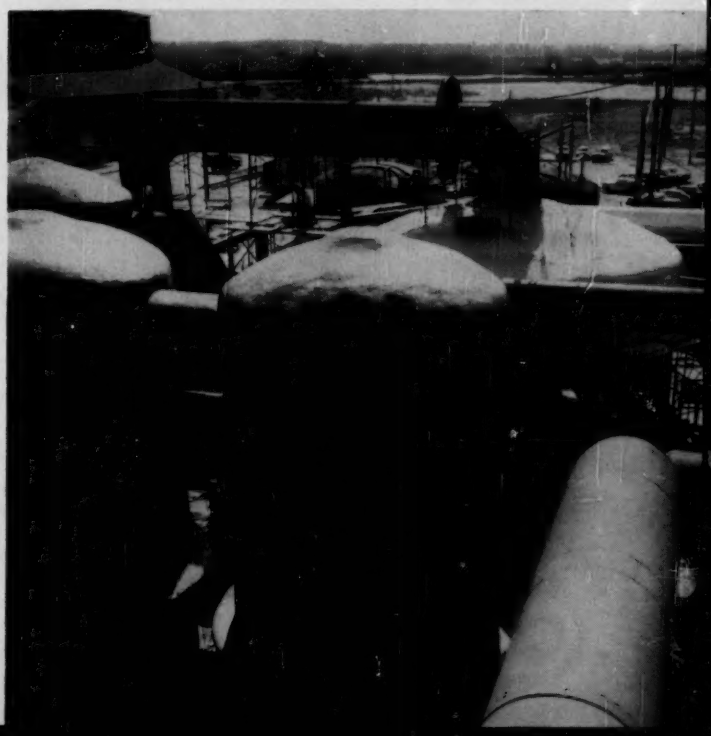


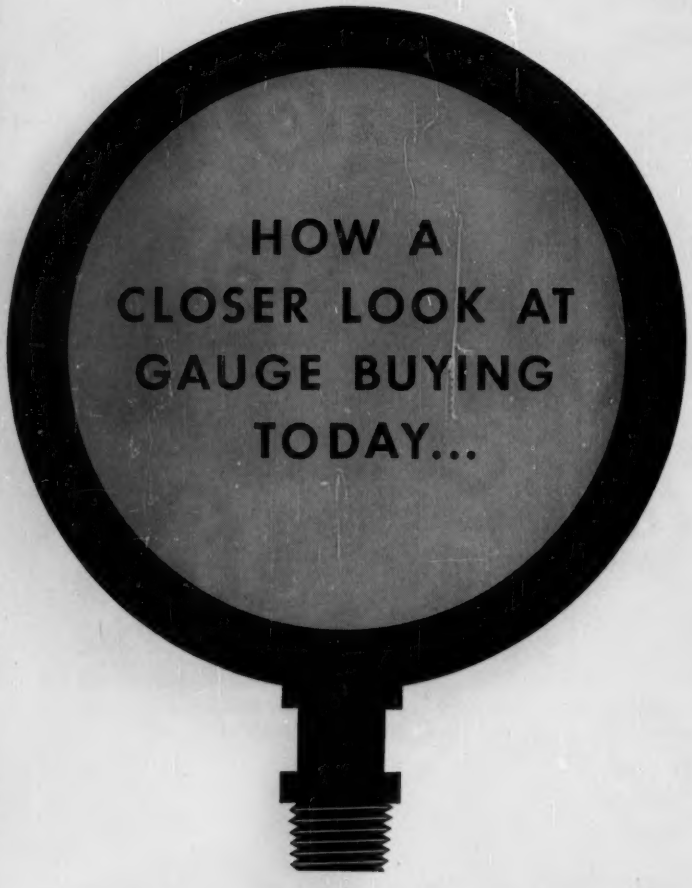
PLANT FLOWSHEET unfolds in this construction photo. Reading clockwise from the bottom: combustion furnace, dust collector, waste heat boiler, scrubbing and cooling towers, acid mist precipitator, drying and absorption towers, exchangers and converter.

he bottom of the first scrubbing tower for blending with 98% acid stream to make a 60 Be. product. A sidestream of SO_3 is diverted and contacts 98% acid in a small absorption tower to make oleum. And a 93% acid product is obtained by withdrawing a stream from the bottom of the drying tower and pumping it through an air-stripping tower to recover any SO_2 that might be dissolved in the acid.

Materials of Construction—Sludge burner consists of a steel shell lined with firebrick. The gas scrubbing tower is made in three layers: a steel outer shell lined with lead with an inner core of acidproof brick. Circulating acid lines and the gas flue from the top of the scrubber are made of Haveg. Gas cooling tower is similar to the scrubbing tower; flue leading from cooler to the mist precipitator is rubber-lined steel. Precipitator itself is lead-lined, followed by a rubber-lined gas flue. Gas flues in the rest of the plant are plain carbon steel. Converter is carbon steel; drying and absorption towers are steel, lined with acidproof brick. Piping for 98% acid is cast iron.

GIANT EXCHANGERS are almost 40 ft. high and 14 ft. dia.





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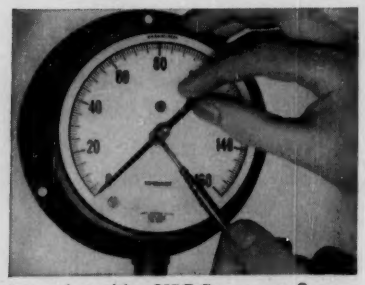

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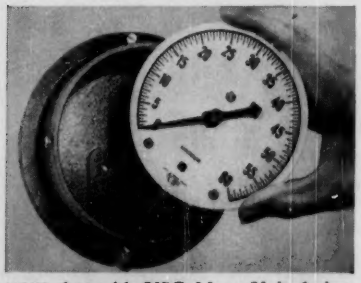

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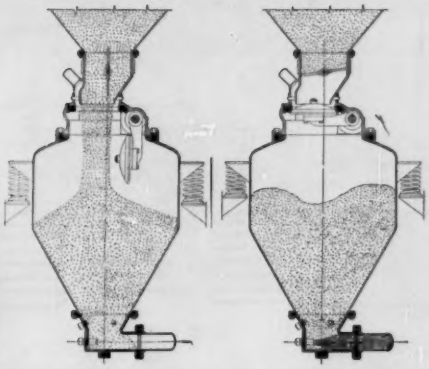

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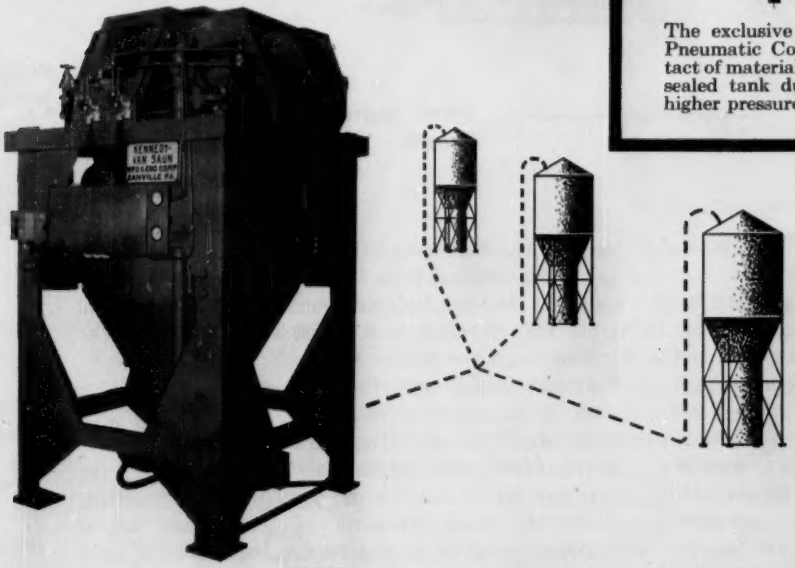

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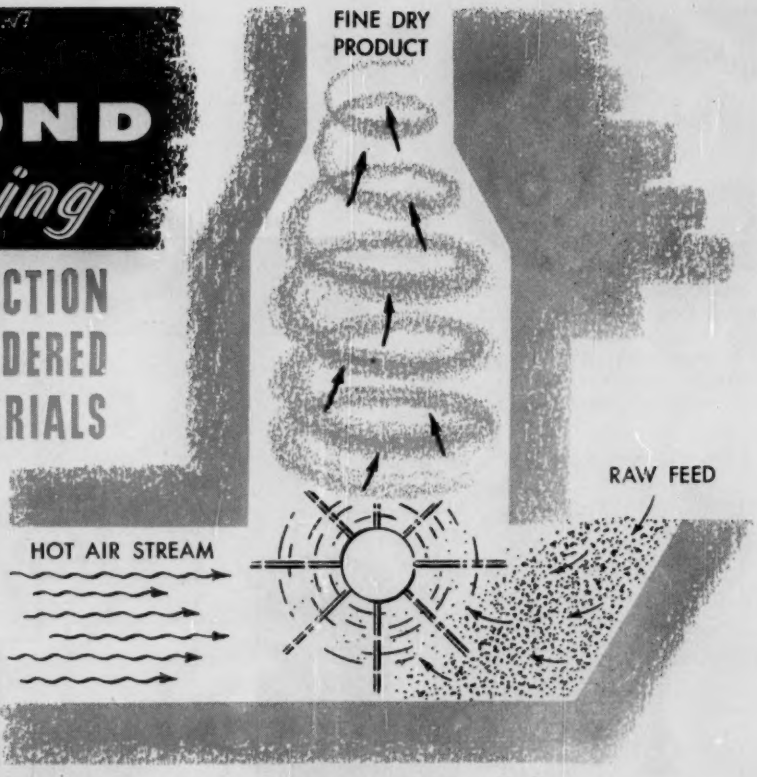
SIMPLIFIES PRODUCTION OF POWDERED MATERIALS



Heated air is circulated through the system, and the raw material is simultaneously dried, disintegrated and delivered as a fine, dry, free-flowing product . . . one operation in a single, compact unit.

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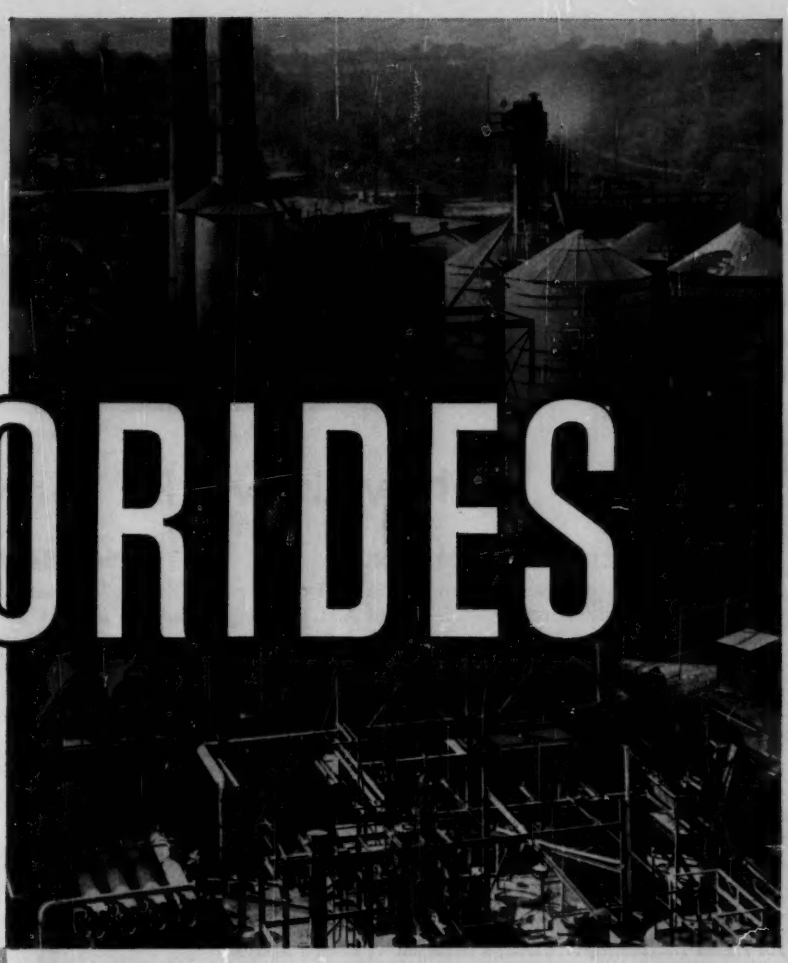
HARSHAW

FLUORIDES



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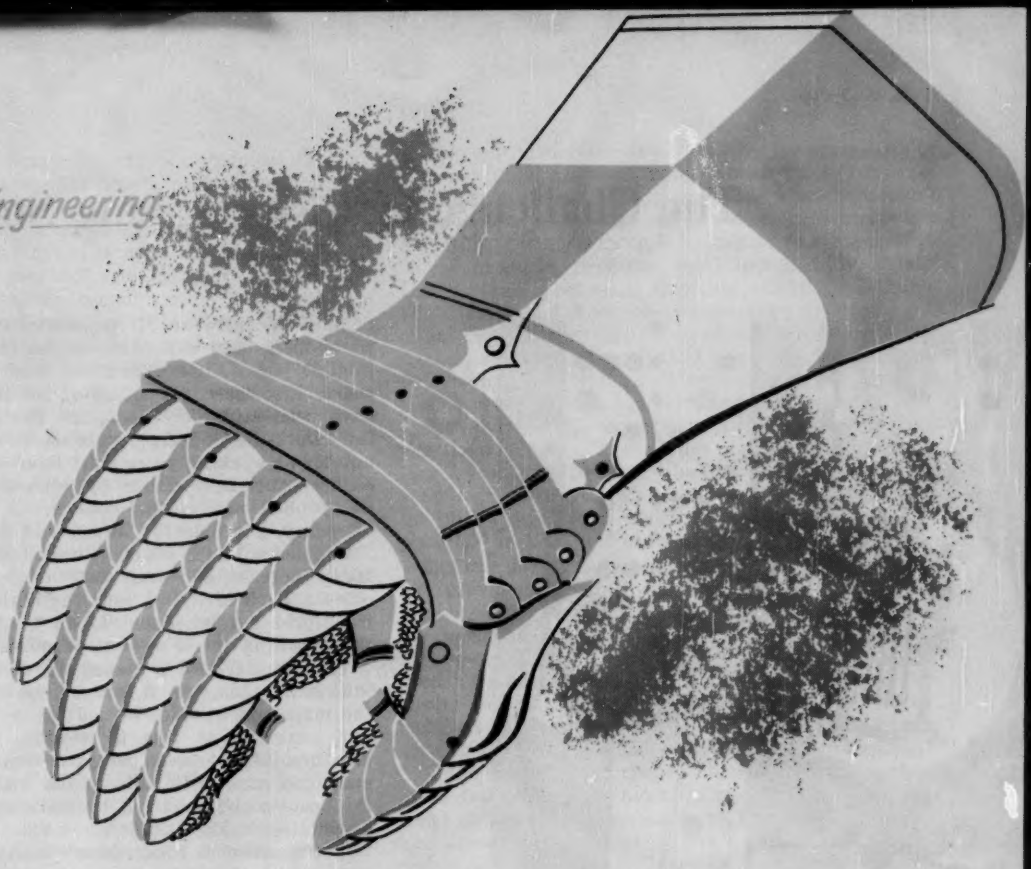
Chemical Engineering
JANUARY 11, 1960



60's Challenge Chemical Engineers

As the world enters the new decade of the 1960's we have more than the usual year-end excuse for stock-taking. The start of the New Century in 1900 was no more significant than this particular juncture in history, for today's problems are far more complex and faster moving than they were in that simple and nostalgic era. So complex have they become, in fact, that we look upon them as "The Challenge of the '60's."

How will the '60's challenge America, the engineer and industry and, particularly, the chemical engineer? We look upon this challenge as in three main parts, and we have so arranged the 14 short reviews and forecasts which follow. These challenges are conveniently discussed as if they were in fact separate and discrete, but they are not; they overlap, they interact and they are part of an ideological struggle where the pawns are not only the markets of the world but the conquest of space, and of men's minds as well.

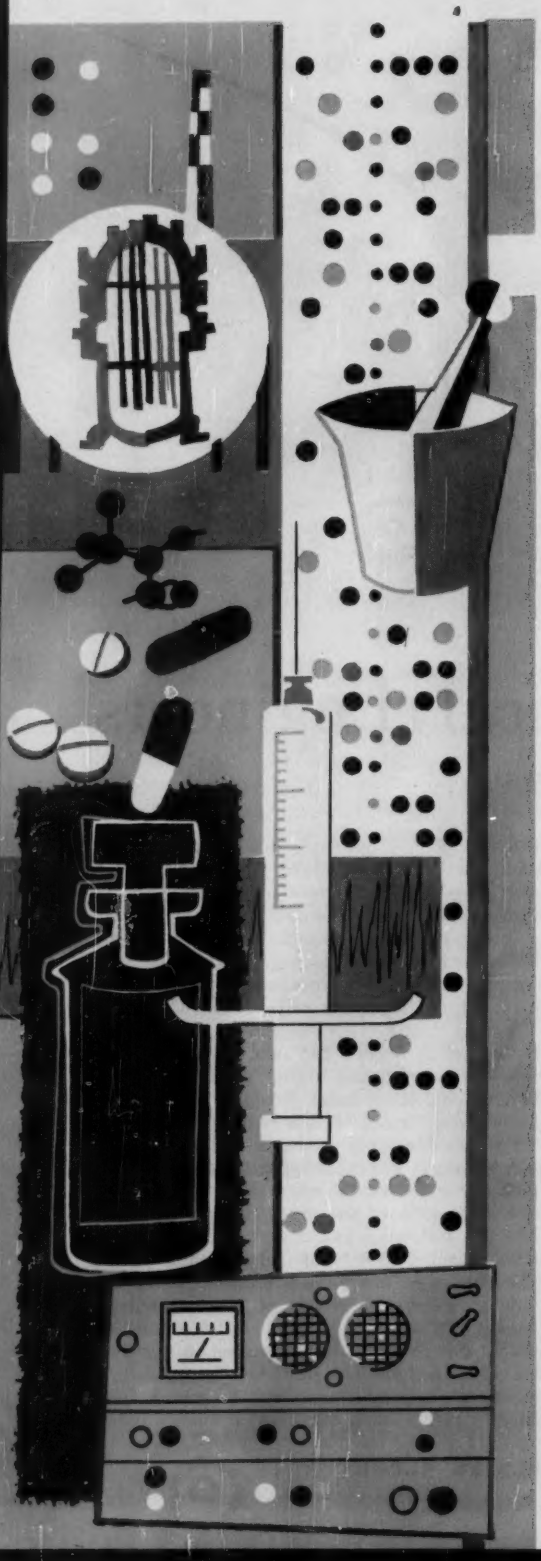
America has long had the world's highest standard of living, and is committed to heading much higher, so the first challenge of the '60's is "The Challenge of Higher Living Standards." This standard is now being assailed, first in the sphere of commerce by a rejuvenated Europe, secondly in the politico-scientific sphere by Russia. Thus, the second challenge is "The Challenge From Abroad."

Both challenges combine to produce the third, which might be called "The Challenge of Rising Costs." An improved standard of living means higher pay and shorter hours, which in turn means higher costs of production. On the other hand, Russia has forced us into a two-pronged race, a race of armaments and a race for outer space, both characterized as a struggle between opposing technologies. Both races are vastly expensive and together take some 10% of the gross national product.

In the following pages and in 14 short articles selected for their relationship to the '60's challenge, we have attempted to review some significant portions of the technologic scene, not overlapping too much the somewhat comparable reviews that appeared in our 1957 and 1958 Annual issues. They bring out in no uncertain way the extent to which technology has become a dominant influence today.

A CHEMICAL ENGINEERING REPORT

The Challenge of Rising Living Standards



Since World War II, populations throughout the world have been expanding explosively. In the U. S. in that period, life expectancy has increased by 4½ years. Elsewhere, percentage if not absolute increases have been still more striking. Particularly in U. S. the "work-life" of the population has been shrinking notably as working years start later—after school and college—and end earlier by compulsory retirement. Our population is getting younger, by decline in infant mortality, and older by increase in life expectancy.

Coupled with the shorter "work-life," and the population increase, is a remarkable degree of pressure on our standard of living, now the highest anywhere in the world but scheduled to go much higher before the decade is out if present promises are realized.

This pressure for a higher standard of living is an interesting thing, for it comes from both the labor and the management sides of the fence. The steel strike, still unsettled as this is written, represents labor pressure. Management pressure toward the same ultimate end came originally in the mass production of the past—to be amplified by the spread of automatic production in the future.

Our economy is a consumer's economy, at the same time it is a producer's economy, since every move toward amplified production must be matched by amplified consumption—hence a higher living standard—else the entire system breaks down.

Under our living-standards heading therefore, we discuss the developments in drugs and medicines that have changed the population picture; the coming day of optimized production practices; the future of nuclear and fossil energy sources and raw materials.

Longevity Increase Brings a Problem

With the increased life span brought about by pharmaceuticals the economic theories of Malthus are due for worldwide test.

Pharmaceutical products are rearranging the historical balance of life and death. In adding to the span of life they bring man a much desired gift—but he must recognize the concomitant problems of population pressure which they inevitably create. With population increasing explosively throughout the world, coupled with a simultaneous demand for higher living standards, technology will be under a fearful strain in the '60's, and beyond, if the Malthusian theory is to be proved incorrect.

Life expectancy in the United States has been increased by 4½ years since World War II. Abroad, especially in Asia, the longevity increases are doubtless still more striking percentagewise. Pharmaceuticals have played the key role, sharply cutting infant mortality and prenatal deaths, while putting many of the age-old enemies such as pneumonia, influenza, tuberculosis and syphilis largely out of the running.

During World War II came penicillin, blood plasma

and its fractions, drugs for control of tropical diseases. Since then have come the broad-spectrum antibiotics; the tranquilizers, both synthetic and natural; the steroid hormones; vaccines against diseases such as polio; and antihistamines to control allergies.

Some familiar foes still remain: heart disease, cancer, mental illness, the common cold. On top of this problem come new ones: can pharamaceuticals help make room for the swelling infant population? Can they help alleviate the aging process in the increasing geriatric population? And can they restore the balance of power among the disease-causing micro-organisms, some of which have developed tolerance toward existing drugs.

Pharmaceuticals' highly effective chipping away at the periphery of man's health problems has provided some concept of their core: the chemistry at the source of life, the idea that all life processes reduce down to chemistry. Work on hormones and steroid compounds has thrown some light on how these substances regulate growth processes and probably control enzymatic processes in living tissue. Advances in the treatment of mental diseases through tranquilizers and, now, psychic energizers lend direction and impetus to further exploration for physico-chemical seats of mental disease.

Discoveries that vastly complex nucleic acids of the cell nucleus, collectively called DNA (deoxyribonucleic acid), and nucleic acids of cytoplasm, RNA (ribonucleic acid) are fundamental to human growth and differentiation processes have recently merited Nobel Prizes. Scientists today generally agree that DNA is an important part of the heredity mechanism.

The effectiveness of research is cumulative. Momentum gathered by the vast research expenditures of the postwar period have led one pharmaceutical executive to predict the following major medical breakthroughs by 1962: A heart disease drug or series of drugs; major new drugs for mental disease; vaccine for the common cold; a cure, instead of palliatives developed in the past, for arthritis, rheumatism and inflammatory disorders. By 1965 he expects a cancer cure. Most promising chemicals at present fall under the following classifications: alkylating agents, antimetabolites, hormones and steroid compounds, antibiotics.

Oral contraceptives mark one avenue down which the industry has made a start toward easing problems created by the boom in babies. Recent clinical reports have indicated a high degree of effectiveness for G.D. Searle's Enovid ($\Delta^{4,\,(20)}$-17α-ethinyl-17β-hydroxy-3-ketoestrene) and Parke, Davis' Norlutin (19-nor-17α-ethinyl testosterone).

Insufficient data about side effects of the products —to say nothing of religious and sociological obstacles —will probably prevent their promotion for contraceptive purposes for three to five years. However, one of them, Norlutin, is already on the market to aid women who have been unable to bear children under certain conditions.

Contraception by pills has been pre-dated by several new oral drugs for diseases generally requiring hypodermic administration. Among them are antidiabetics (sulfonylureas), diuretics (chlorothiazides) and even polio vaccine. It's easy to see how the simplicity of pill-taking may help overcome the resistance of undereducated, overpopulated countries to more complicated methods of birth control.

Two new penicillins have just been introduced which are not only oral but also partially the result of chemical synthesis. For many years after penicillin's introduction, chemists could not even describe its structural formula, much less attempt to synthesize it. These products, produced by Pfizer and by Bristol Laboratories (α-phenoxypropionic acid with 6-aminopenicillanic acid, and potassium α-phenoxy-ethyl penicillin, respectively) are expected to prove more active against resistant germs. Other originally natural products which have yielded to synthetic modification in recent years include the corticoid hormones.

Extension of life expectancy that has resulted from the introduction of new drugs has been reflected in increasing importance of diseases of the heart, blood vessels and kidneys. One industry leader predicts that by 1975, deaths from heart disease, standing at 5.13 per 1,000 in 1956, will have been cut to 4.40.

Medical use of the corticoid hormones for arthritis has provided a palliative, not a cure. Alteration of the body's hormone balance by using estrogens, female sex hormones, to treat cancer of the prostate, and androgens, male sex hormones, to treat cancers of the breast, is useful procedure today. But common side effects include virilization and feminization. However, isolation of the steroid hormones has added to knowledge concerning chemical control of body processes.

Tranquilizers (reserpene, chlorpromazine, mebromate and others) do not cure mental illness, but do make patients more amenable to psychiatric therapy. The new psychic energizers (Warner-Lambert's β-phenylethylhydrazine, Geigy's dibenzazepine derivative and a Pfizer product, all introduced last year) don't eliminate the need for psychiatric help, but they do stimulate mind and mood, reducing the need for electric and insulin shock treatments. And success of these drugs in treating mental illness suggests new chemical links between body and mind.

DNA discoveries have not yet made it possible to stop cancers' growth nor to direct hereditary characteristics. But they have already provided insight into the sequence of events involved when cells divide and living tissue grows.

The pharmaceutical industry has flourished amazingly in recent years, in the same free economic climate that has nourished the rest of American industry. Quite possibly, without the incentives of profit and competition afforded by this climate, the tremendous research expenditures necessary to develop the marvelous new drugs would never have been made.

Now, however, competition in the industry has become most intense. Many proprietary drug companies are invading the ethical drug area. The rate of product obsolescence is quickening. Price weakness has cut into profit margins as productive capacity on many major product groups has come to exceed demand. For many major firms in 1959, percentage gain in foreign volume is believed to have been much greater than the increase in domestic revenues.

On top of these difficulties, certain business practices of the industry have been under fire and the question has been raised as to how compatible is the industry's enormous influence over health and welfare, with the competive, profit-making activities of normal business. Technological advances of the '60's may well emphasize that the pharmaceutical industry is more than just another business.

More From Less With Optimization

Fancy new word for an old idea, process optimization is being sought by new paths of mathematics, computers, instruments.

With population pressure and the urge toward higher living standards on the one hand, opposed by enormous military requirements, scarcer raw materials and rising costs on the other, engineers must turn to whatever tools will accomplish the magic of making more from less. Call it optimization or what you will, the engineer must still seek to hike efficiency, reduce waste.

Optimization is a generic term which links various technical ideas and methods to improve both the technical and the economic operation of an enterprise. Real operations generally involve many variables and it becomes difficult to discover the best relationships. However, optimization techniques can ease the job of finding the most suitable conditions and interactions. In several chemical firms today there is already acceptance of these methods.

Optimization techniques are drawn from the realms of the mathematician, communications engineer and servomechanisms designer. They fall into such categories as systems engineering, operations research and process control engineering. The mathematician contributes in several areas: statistics, symbolic logic, numerical analysis, mathematical model formulation. Each of these branches of math is important background for the optimizing engineer.

Statistics is a world of regression analysis, of factorial design, of evolutionary operation. It's a world available to everyone's budget—the smallest one-plant company and the largest chemical complex. Statistics helps organize experimental approach and the data gained from experiment. It picks out process parameters to find the best mathematical description of a process. And it helps, through evolutionary operation, to select the best conditions of manufacture in an existing plant.

Symbolic logic and numerical analysis are the backbone of electronic computer application. Logic makes possible the design of computers and eases the programming effort. Numerical analysis translates mathematical expressions into arithmetical form that digital computers can digest.

Still more important, perhaps, in the decade ahead is the formulation and refining of mathematical models. Models show quantitatively what a situation is—whether it be a process, the administration of a business or a competitive battle. A model is an equation or set of equations that interrelates real problem variables.

In the years ahead—through game theory, management "games," stochastic mathematics, dynamic analysis—models will be constantly improved as engineers seek answers to more difficult questions. Models will not only give the answers, they will also lead to optimum control of both man and machines' energies.

Computers, both analog and digital, are central to most optimization programs. This because they make it possible to compute faster and cheaper. By assuming an essentially dull task, they free man to examine more critically the activities of the economic enterprise.

Faster computing is an optimization essential because optimizing techniques depend to greater or less extent on consideration of thousands or even millions of alternative possibilities. By speedily weighing these alternatives and selecting the best, the answer can be applied while it still can make profit for the enterprise.

And where are computers used? Right now, so far as the engineer is concerned, they are important for three major areas—as well as a host of others. These are statistical, process design and production studies. All of these duties are "off-line," that is, the computer is an engineering tool and has no physical connection with a real process or operation.

The '60's will see widespread application of computers to closed-loop process control of existing plants or portions of plants. Already a few scattered applications have been reported. What stands most in the way of this use of computers is quantitative process understanding. Engineers who thought they understood what goes on physically in the processes they design and supervise have had to revise their estimate. Computers, they have found, are unrelenting in their demand for absolute understanding.

Computers of the next ten years will be faster, have more storage capacity. More companies will use them; more engineers will feed them problems. Engineers will find them easier to use, even on difficult problems, because of programming developments that promise easier-to-talk-with machines. Program languages will make it possible to use one generalized program on several different machines. Too, there will be greater program interchange, both intra- and intercompany.

Some ideas for optimizing have trickled down from communications (information theory) and servomechanism design (frequency response). Ideas that originally cured electronic and electromechanical systems difficulties now are taking root in process industry areas—particularly in process control.

These ideas have led to the "systems engineering" approach which, briefly, is: analyze, synthesize, specify and test.

Control of processes is old hat to the chemical industry, but it's only in the past few years that the key to process control design has been cut—the key of process dynamics. But even now, although the techniques are available, the key has not been turned in the lock of classical design, design for the steady state.

If the key fits and the lock turns, the door could well be opened in the coming decade. Behind the door are unrealized profits, better products, tighter processing. Chemical engineering curricula are being reorganized to include academic exposure to computer and control technology. With increasing recognition of the realities of dynamics problems, this will tend to take some of the fat out of new designs and increase productivity of existing plant.

However, increasing recognition of the dynamics problem will demand better components for instrument systems. Already there are definite trends to watch. Electronic control—until only recently a bug-a-boo to process men—will assume an important place. In existing electronic installations today, reliable, maintenance-free operation has been the rule. Where centralized control and fast response are required, electronics will supplant the now-predominant pneumatic control.

Another instrument trend will be the rise of closed-loop control where an analytic instrument is the primary element. Rather than to measure temperature, pressure and flow as at present, and from these to infer quality, engineers will insist on controlling what they're actually selling—composition, viscosity, color and the like.

As for optimization through control, that is where the process control computer will assume its role. The decade ahead will be one in which computers are compared, selected, rejected and applied in closed-loop control. Chemical companies, anxious to preserve know-how, will form their own groups to investigate computer control feasibility.

In all probability, the next ten years will not see the computer designed into new processes, nor used to control processes directly. Instead, computers of all sorts will be applied to existing process plants, exerting optimizing control by determining and adjusting the set-points of conventional controllers.

Nuclear Energy Makes Progress Slowly

Striking breakthroughs are unlikely in the next decade. Expect instead concerted effort to improve fuels and reprocessing.

Our adolescent nuclear industry has been having growing pains. Top management is counseling patience—give the youngster a chance to grow to grow up, they say. Growing up, whether in the human, or in a new technology, takes time and they doubt that the next decade will show much more than steady progress. Nuclear headlines of technological breakthroughs will be few and far between.

All over the world, industries and governmental agencies are mapping out their programs for major technical effort in the years immediately ahead. Nuclear fueling, reactor development, fuel reprocessing and work on radiation applications are the areas of concern in the competitive atoms-for-peace picture.

Perhaps the most significant barrier to competitive nuclear energy today is the high cost of reactor fuels. Largely responsible is the great complexity of feed material processes. Efforts are under way in several directions to improve these processes. Chemical engineering techniques borrowed from petroleum and chemical industries are already making headway and soon may go even farther in cutting processing costs. Fluid-bed, fixed-bed and flame-reactor techniques are competing for roles in the feed material picture.

A change in the feed preparation scheme which promises to reduce costs will be to sweeten purified natural uranium metal right at the mill with high-enrichment metal made by presently prevailing processes. Thus partial enrichment of some fuels can be eliminated.

On the foreign nuclear scene, natural uranium remains the leading material for reactor fuel. And, world-wide, uranium still holds more promise as the prime nuclear fuel than thorium.

But reactors are being developed to burn a variety of fuels. Euratom, U. S. and other world nuclear powers are focusing development efforts on some seven basic designs: pressurized-water, boiling-water, organic-moderated, sodium-cooled, heavy-water moderated, gas-cooled and fast-breeder reactors.

Euratom's president, Etienne Hirsch, reported at last year's annual Atomic Industrial Forum conference that within the next five years Europe's first generation of nuclear power reactors will be in operation. Designs favored in Europe—boiling-water, heavy-water and organic-moderated—are particularly suited to operation with natural uranium fuels. Europe's inability to enrich uranium in U-235 by gaseous diffusion is the basis of its choice of reactor design. Italy, West Germany, France, Netherlands and West Berlin will be the first to install the new series of 150-mw. reactors.

Impact of increased construction of small-scale nuclear power reactors will, surprisingly enough, have a catalyzing effect in promoting construction of larger power reactors. As volume of uranium-fuel consumption increases, fuel preparation, fuel reprocessing and reactor construction costs will all drop. When fuel reprocessing reaches the scale where profits are possible, industry will take over.

In anticipation of this growth, U. S. Atomic Energy Commission's laboratories are continuing their efforts to improve nuclear fuel reprocessing techniques and develop new techniques to reprocess newer reactor materials such as zirconium and columbium (niobium).

Techniques are being developed to handle the radioactive wastes which result from reprocessing of nuclear fuels. Such methods as concentration of radioactive materials by calcination and absorption in silica show some promise. But as some industry representatives point out, before a third generation of power reactors can be constructed, the problem of radioactive waste disposal must be licked. If it isn't solved by then, a sizable portion of the earth's surface will be covered with storage tanks for "hot" liquids.

Industry attention is gradually (but still only slightly) turning to radiation for processing purposes (*Chem. Eng.*, Nov. 16, 1959, pp. 100-104). If present research efforts are as fruitful as they promise to be, radiation will eventually hold its head high in the chemical processing industry.

And if industry and government continue to team their efforts as they do now, the nuclear industry will blossom within the next 10-20 years.

Fossil Fuels Still Carry the Load

For the next decade nuclear energy will continue to provide under 10%. Meanwhile gas and oil remain the big contending energy sources.

During the '60's you can expect to see a tremendous increase in demand for energy, most of it borne in the immediate future by the fossil fuels—coal, oil, gas.

Continuing availability of the three fossil fuels is unquestioned, but economic interplay among them will govern ultimate choice by the user. This economic interplay will reflect costs of production, transportation and utilization for each fuel.

Current trends in meeting the increasing energy

demands of the world economy seem geared to the more extensive use of natural gas here in the United States. Greater consumption of oil can be expected in the rest of the world.

During the decade of the '50's, energy supplied by natural gas expanded at about twice the annual rate for petroleum in the United States. In Western Europe, huge supplies of coal are unused because of the greater availability of petroleum products.

In the U. S., we can expect that fuel needs for generating electrical energy will about double in the forthcoming decade. Most of the fuel to provide this energy will come from bituminous coal. However, in certain areas of the U. S., residual oils, or natural gas, or both, will battle for this expanding market.

Outside electrical generation, oil and natural gas will supply the major source of U. S. energy. Approximately three-quarters of all U. S. energy requirements will be supplied in equal shares by petroleum products and natural gas in the coming decade.

Technological advances, however, may influence cost of coal transportation. For users of pulverized coal, cost reductions in transportation charges are possible through greater use of solids pipelines. One such pipeline is already in operation in Ohio. Another, still in the proposal stage, may move coal from West Virginia and western Pennsylvania fields to the east.

Large scale users of energy may find attractive prices for natural gas because of its increasing availability in consuming areas. Purchase of off-peak and off-season capacity in natural gas pipelines offers substantial cost reductions to users on an interruptible basis. For these users, alternate fuels may range from petroleum products to pulverized coal.

We may witness further expansion of over-the-fence exchange of fuel, or makeup water, or both, for process steam and electricity between chemical plants and electric utility plants. A number of such tie-ins already exist; more are likely to follow.

Energy from nuclear sources in the coming decade depends, in large measure, on its competitive position relative to fossil fuels. Estimates of energy to be produced from nuclear sources range from 1 to 10% of all energy requirements of the world. Continued research in nuclear fuels and nuclear reactors can be expected to yield lower costs for nuclear energy, but more than 90% of all energy will be derived from mineral fuels in the decade.

Most Raw Materials Still Plentiful

Unlike steel and copper industries, most CPI plants have no raw material shortage worries—except water, in some areas.

The engineer concerned with the problem of supplying an ever higher standard of living to a rapidly increasing population is justified in being worried over raw material supply. He looks at the problems faced by steel and copper, for example, and thinks: "Could this happen to me?" Fortunately, so far as the chemical process industries are concerned, there will be few startling changes in sources of basic raw materials during the next decade.

Derivation of synthetic organics from petroleum and natural gas sources will continue to assume ever-increasing importance. R. L. Bateman, of Union Carbide Chemicals, estimates that by 1965 the production of such petrochemicals will be around 85 billion lb./yr., exactly double the 1958 figure. Petroleum- and gas-based chemicals will account for 32% of all CPI production in 1965, compared with 28% in 1958.

Some industry observers believe, however, that the end of the '60's decade will see some reversal in the trend toward petroleum sources for synthetic organics, and back toward coal. They point to the rising prices of oil and natural gas while coal prices have remained relatively constant. This fact, coupled with a demand for synthetic organics of around 130 billion lb./yr. by 1970, leads some to believe that a breakpoint will be reached where coal will again be an economical source of chemicals.

Other chemical raw materials like sulfur, potash, salt, phosphates, nitrogen and oxygen are all in plentiful supply. Joseph L. Gillson, of Du Pont, speaking at the recent AIChE meeting in San Francisco, noted that the CPI problem is mainly one of improving processes to lower production costs; it is not a problem of searching out new material sources. Gillson noted, however, a few minor changes occurring in raw material supplies. Reserves of chemical-grade fluorspar, for example, are dwindling, but there is hundreds of years' supply tied up in Florida phosphate rock. Kaiser Aluminum, for one, is already recovering fluorine as a byproduct from Florida fertilizer plants for use in manufacture of synthetic cryolite.

Probably the most important single CPI raw material—water—will be of growing concern in the next ten years. Although certainly not yet a critical item, water availability is already a problem in many industrial areas. In areas like the Southwest and southern California, water shortages are already apparent and will be much more serious in the '60's, leading to two courses of action: greater conservation, or erection of seawater desalting plants. Under the conservation heading come measures like increased water reprocessing and recycling, and use of air for cooling.

On the desalination front, the Department of the Interior has already earmarked $10 million for five desalting demonstration plants. Andrew Chekovich, of Singmaster & Breyer, estimates that in the world today, some 11 mgd. of fresh water is produced from the sea. This number, he believes, will jump to 20 mgd. by 1965. In the U. S. alone, additional water production by 1965 will be around 5 mgd., mostly from the demonstration plants.

As for costs, Chekovich believes that the present $1.20/1,000 gal. can be cut to 50-60¢/1,000 gal. in a 3-mgd. plant through refinements in present technology. In a 25-50-mgd. plant, costs could probably be pared down to 37-40¢/1,000 gal. Only down in this last range will areas other than the most water-hungry be able to afford water from the sea. In special areas, of course, fresh water can be made from brackish water at lower costs than the seawater plants.

One of the most troublesome shortages in the U. S. is in high-grade iron ores. At the same time, conveniently placed deposits of coking-grade coal are playing out. There are three avenues of approach to this combined problem: First, processes are being developed to beneficiate low-grade taconite iron ores at

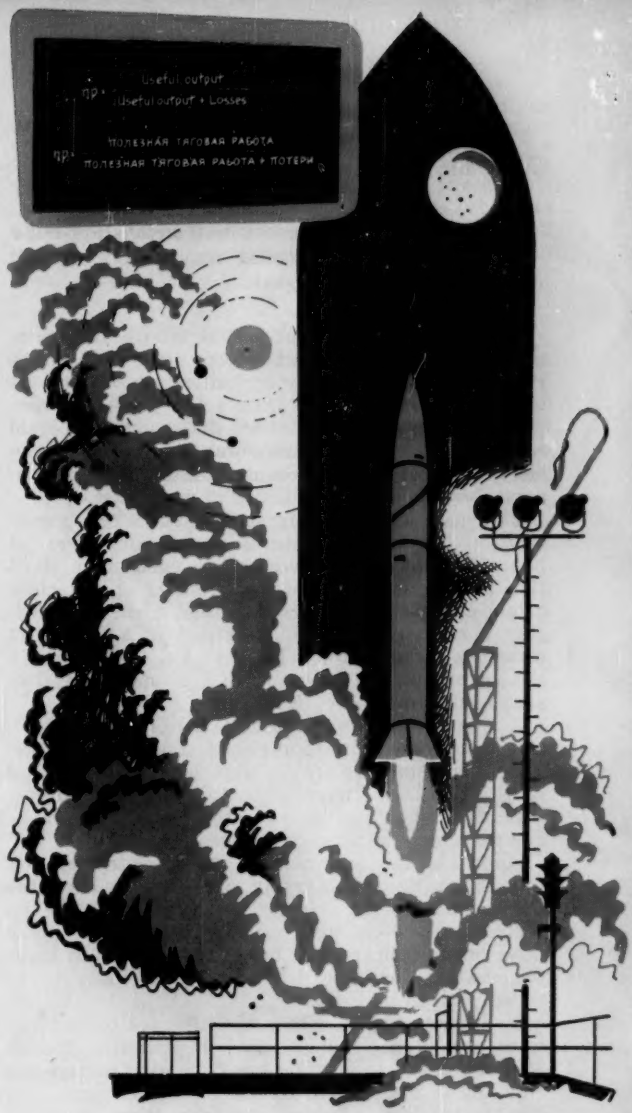
the mine site. By 1970 we will probably be using over 35 million tons/yr. of taconites, compared to around 14 million tons today. Using taconites, of course, means higher mine investment and higher production costs. Alternatively, steel mills are depending less and less on domestic ores, are locating near waterways to take advantage of high-grade foreign ores.

Most radical change in the steel picture is the growing number of attempts to bypass the blast furnace entirely and eliminate the need for coking coal. Two significant developments in the past few months set the stage for more startling developments that are sure to come in the '60's. The Strategic-Udy electric-smelting process will be used in two new plants (*Chem. Eng.*, Oct. 19, 1959, p. 95) and the Mexican HyL process is slated for a new plant in Canada.

Much the same is true with other metals. There are no real shortages in sight, but deposits of high-grade minerals are disappearing. Copper is a prime example. High-grade sulfide deposits are almost exhausted in U. S. and many mills operate on ores containing less than 1% Cu. The big untapped source of copper lies in the huge deposits of low-grade oxidized ores; technology exists to win copper from these ores, but it is an expensive proposition. A brand-new economical process would be a boon to the industry.

In aluminum, companies are turning to high-silica bauxites, such as those in Arkansas, that would have been uneconomical a decade ago. But now that industry has developed ability to handle the "difficult" bauxites, there is no shortage in view. An official of Kaiser Aluminum notes that at present rate of growth, its Jamaican deposits alone will last 40 years.

Another potentially new source of raw material is our almost limitless storehouse—the sea. Already providing bromine and magnesium from its water, and petroleum and sulfur from undersea domes, the sea also contains minerals on its floor and could be "farmed" for food, according to the International Geophysical year. But all of these proposals are at a very tentative stage now.



The Challenge From Abroad

During the late '40's—up to Korea—America had things pretty much its own way in the world. But, being a nonaggressive nation, we did our best to provide the help to other nations which eventually would be turned back at us in competition. And now the competition has grown to a point where it demands an answer in better military engines, in more powerful rockets, in cheaper goods and services, if we are to hold the place in world affairs we believe we deserve.

This challenge from abroad comes in three forms. No longer worn to a shadow by the second World War, Europe is now back in the world markets with prices we cannot touch. The Europeans have learned our production methods, they have rebuilt their plants with our financial and technical help, they have borrowed our design and construction techniques and now they want nothing more from us except a free hand in the markets of the world.

Even more serious is the politico-scientific challenge—with military overtones—which Russia has built up to in the last half dozen years. Russia's challenge is a political, technological, military system, later to be supplemented with competition in the commercial sphere when the production machine has been built to a point where this is possible. The challenge commenced in the military sphere, then—when a stalemate was achieved—shifted to a contest of competing technologies and of educational systems at which we appear to be not quite holding our own. The object is mainly to advance their political system in the eyes of the world, and eventually to gain commercial sway for Russian products.

In this section of our Report, therefore, we have concentrated articles dealing with several aspects of the technological challenge, including the attainment and application of very high and very low temperatures, the development of rocket fuels, and advancement in the field of engineering education.

Cryogenic Temperatures Becomes Usual

Rocket fuels, super-conductive metals, low-noise electronic gear, liquefied natural gas are all products of the cryogenic age.

In large part as a result of the missile race, temperatures near the bottom of the scale that a few years ago were laboratory curiosities are now becoming almost commonplace. Only a few years ago temperatures below that of dry ice were unusual. Liquid nitrogen provided cold traps for laboratory experiments. Almost the only commercial use for low temperatures was in the production of pure gases.

The space age has changed all that. Where superconductivity at temperatures approaching that of liquid helium—4.2 K.—was only a curiosity a short time ago, it is now a practical property of materials, valuable in electronic work. Further, when this property was first discovered, it existed in a few select materials at temperatures less than 5 K. Now research has discovered new alloys which are super-conductive at temperatures above 15 K.

At temperatures near absolute zero, molecular motion almost ceases. Inherent electrical noise also ceases, making possible electronic amplifiers of unheard-of sensitivity. These "masers," operating at the temperature of liquid helium, have greatly expanded the range and usefulness of radio telescopes and radar.

An infrared detector must be at a lower temperature than the radiation it is trying to detect. The lower the temperature of the detector, the greater will be its useful range. New, small refrigerators can cool these detectors to temperatures below 100 K., a much lower temperature than the detector is ever likely to be called upon to measure.

Hydrogen, oxygen, helium, methane and other gases were usually handled as gases in cylinders, though some work on a small scale was done with storage and handling of oxygen and methane in liquid form. The new technology, however, demands these gases in tremendous quantities. Hydrogen, for instance, is the best chemical rocket fuel but it must be in liquid form to be useful. The gas occupies too much space. New insulations now allow storage of large quantities of liquid hydrogen for rockets and other uses. These same insulations also permit shipment of liquid helium cross-country by tank truck, a much more economical method than cylinder shipment. Liquefaction of methane in natural gas need no longer be a small-scale local operation. It is now possible to ship methane overseas by the tanker load.

What of the future of low temperature? Shipment of liquid methane to gas-hungry areas of the world will become a commercial commonplace. Blood banks will store whole blood for years at the temperature of liquid nitrogen. Other human spare parts will be similarly stocked. Super-conductive cryogenic devices will receive wide use in computers, communication equipment and other electronic gear. Some of the more exotic of the proposed rocket engine designs depend upon magnetic fields maintained in super-conductors for their operation.

The average individual is not likely to be directly concerned with these very low temperatures. But cheaper power and new materials developed with the aid of cryogenics may profoundly affect his standard of living. No longer science fiction, perhaps the blood or bones of a person long dead may someday save his life. And who knows? Suspended animation at 2 K. may eventually get him to Alpha Centauri.

Highest Temperatures Await Containment

Earth-bound temperatures are advancing slowly but temperatures met in rockets have strained our ability at containment.

Just as low temperatures have been spurred on by our developments in rockets, high temperatures too have gone into new territory and, in fact, are on the threshold of a major revolution in high-temperature generation and containment. Here are a few straws in the wind:

In electric power generation, top steam temperatures have increased an average of 12 F./yr. over the last 50 yr.

Contact sulfuric acid plants have boosted operating temperatures an average of 5 F./yr. since 1950.

Jet engine turbine inlet temperatures have gone up an average of 15 F./yr. since 1940. In some engines, turbine blades now must withstand 1,600 F.

It would be misleading to call the chemical industry a high-temperature industry. Nevertheless, the trend is up, for increased yields and reaction rates. A significant number of process industries do involve temperatures of 1,000 to 2,000 F., many of these fairly recent. HCN, for example, is made from methane and ammonia at 1,800 F. Still higher temperatures would improve the process and eliminate the catalyst. The Wulff process for acetylene involves cracking of natural gas at 2,600 F. Acetylene yield goes up with the temperature, so operating at 3,000 F. would improve the process, at least from the yield standpoint. Tennessee Eastman, in fact, has developed a natural-gas-cracking process for acetylene in which the combustion temperature is 4,530 F.

Progress in high-temperature techniques has been relatively slow in the process industries—for good reason. A chemical engineer working for a profit-minded company must keep his eye on the dollar sign. High temperatures are expensive to generate and contain, and these costs must be weighed against the process improvement resulting.

Most spectacular advances in both generating and containing high temperatures have been in the government-supported rocket and missile industry.

During the combustion of a rocket propellant, temperatures of 6,500 F. are developed. Now engineers are talking of nuclear reactors developing 5,000 F. before nuclear power can become economical in the U. S. (Fusion reactor temperatures, of course, would involve 2-5 million C.).

Other high-temperature areas include vacuum and controlled melting of metals on a commercial scale; solar and arc-image furnaces; plasma jets which now allow production of high-melting-point materials previously prepared only by powder metallurgy techniques. In the forming area we have explosive shaping and electron-beam welding.

One trend which should take definite shape in the next decade is the use of nuclear reactors for process heat. A gas-cooled reactor operating at 2,500 F. could be hooked into a methane reforming process, with significant cost advantages.

It's no great trick to design a process or a rocket operating at a high temperature. The big problem is how to contain this temperature.

Below about 1,800 F., we are in good shape from a material standpoint. For instance, titanium alloys are important materials of construction for service at 1,200 F. High-strength steels such as martensitic stainless, low-alloy (4340) and precipitation-hardening steels are also good performers up to 1,200 F.

The super alloys, based on nickel, cobalt or iron, popular in gas-turbines, fill the bill in the 1,200-1,800 F. range. But 1,800 F. is just about the top temperature limitation for these alloys in oxidizing environments—probably only marginal improvements will come from continuing alloy and fabrication research.

Above 1,800 F. there is no tough, metallic material available now which is completely satisfactory for service in oxidizing atmospheres.

We have nonmetallics—refractories, ceramics, carbon—which are capable of handling temperatures of 3,500 F. and above. Graphite has good strength up to 4,530 F., with low density and good thermal shock resistance. Its poor oxidation and erosion resistance can be bettered with silicide and carbide coatings.

Aside from graphite, most structural ceramics and refractories lose their strength as temperature increases. For furnace and vessel linings, tubes, rocket nozzles, nose cones, they are fine. But they can't be considered as "general" materials of construction.

What we need—and don't have—is metals capable of handling temperatures over 2,000 F. Hope lies with the so-called refractory metals—tungsten, tantalum, rhenium, molybdenum, columbium (niobium), chromium. All these metals have melting points above 3,000 F. but each has distinct disadvantages. Molybdenum undergoes oxidation at 1,200 F. Chromium is brittle at room temperature. Tungsten, with a 6,170 F. melting point, is very difficult to weld and is also brittle at room temperatures.

Columbium and Cb alloys hold the greatest possibilities in this area. New Cb alloys containing tantalum and zirconium have very low oxidation rates at 2,000 F., compared to pure columbium.

Even here, many experts believe the top limit for Cb alloys will be around 2,500 F.

Improvements in tungsten are also coming along. New forging techniques permit production of simple shapes and we can soon expect rapid development of ductile tungsten alloys.

Of course, even these refractory metals have definite temperature limits. The highest melting material reported is a combination of the carbides of tantalum and hafnium, melting at about 7,200 F. In rocket re-entry, 7,200 F. is at the cold end of the spectrum. One idea, for containment of really high temperatures, is the possibility of making high-temperature "metals" out of nonmetals such as ammonia and hydrogen.

All this does not exhaust the contents of the "Pandora's Box" we've opened. We know little about welding and fabricating the new high-temperature materials. But, it is in this area that we shortly may see major improvements. Through fine-particle strengthening, "whiskers," and ductile ceramics, the experts are beginning to understand why materials behave as they do, and how they behave. From this work we can perhaps turn brittle materials into ductile—and join a metal to anything through welding.

Rocket Lag Is Biggest Challenge

Overcoming the Russian rocket lead may be the decade's most important challenge to American scientists and engineers.

Apart from any other evidence, the Russian moon shot left no doubt that Russia has piled up a spectacular lead over the U. S. in the race for outer space. However we may feel about the practical importance of putting men into space, it cannot be denied that the propaganda and military byproducts of the Russian accomplishments are dangerous to the U. S., especially in the struggle for ideological and political prestige which our two systems have been waging.

It is up to us in the decade ahead, therefore, to overtake the Russian lead and forge ahead if possible. More than any other, it's the job of the chemical engineer. To him will fall the largest share of the burden and the excitement of the space-age challenge. For it is his task to develop the rocket propellant systems that eventually will hurl manned vehicles beyond gravity.

Chemical engineers have already chalked up remarkable advances on this job. We have our Vanguard, Explorer and Pioneer space probes, we have our Thor, Atlas and Jupiter missiles. And we have the propellant systems to make these magnificent "birds" fly: the liquid fuel-oxidizer systems like oxygen and alcohol, nitric acid and hydrazine, hydrogen peroxide and kerosene; the various solid systems of plastics and rubber, and inorganic oxidizers. Nevertheless, if today's space vehicles and their propellant systems would have taxed the imagination of even the most visionary in 1950, they will be as outdated as the gods many are named for in the decade ahead.

Space flight in the next ten years will demand propellant systems that join in virtually ideal combination three often mutually contradictory properties:

- They will have to offer specific impulses—the measure of pounds thrust per lb./sec. of gas exiting from rocket engines—of over 400 sec. This means propellant systems that have exceptionally large energy releases, teamed with very light combustion products.
- They will have to be very easily handled, transported and stored—for example, have low toxicity, be chemically stable, exhibit little fire hazard or corrosiveness. At the same time they can add only a minimum of weight to and take up a minimum of space in the missile they are to drive.
- They will have to be commercially available to be able to be manufactured in large volume at relatively low cost.

What materials or, for that matter, what propulsion techniques will combine these virtues is the most perplexing question currently facing chemical engineers in rocketry. A large group believes that the answer will be found in liquid oxidizer-fuel systems. Another large and rapidly growing group holds that solid mate-

rials will satisfy the '60's propellant needs. Still others maintain that the usual solid or liquid propellant combustibles, in fact, combustion itself, are hopelessly inadequate for the coming age. They look instead to nuclear fission and fusion; and, in outer space, to such exotic systems as ion propulsion and free radicals.

Arguments for liquid systems center on the fact that such propellants offer the highest specific impulses yet achieved. Furthermore, since it's possible to control liquid flow, speed of liquid-propelled rockets can be varied and controlled once in flight. On the other hand, liquid-propellant systems are difficult to handle, demand complex and touchy mechanisms that undercut the reliability of the rockets they are to drive.

Solid systems are much easier to handle, requiring only the simplest of propulsion mechanisms. This makes for easy-to-fire, reliably performing rockets. But once a solid-propelled rocket has been fired, there is little that can be done to control its speed. And specific impulses available with solid propellants are markedly below those available with liquids.

As for the more exotic propellant concepts, these promise specific impulses far above even the best of the liquids. But, in their present embryonic state of development, they are suited only to use beyond the atmosphere. Also, they are inordinately expensive and raise many problems still far from solution.

In each camp, engineers are now tackling the job of heightening the advantages and diminishing the shortcomings of the propellant system they favor. Among liquid's supporters, this means pushing specific impulses ever higher and finding schemes for reducing the handling difficulties.

From the point of view of specific impulse, liquid-propellant systems made their most significant advance when liquid hydrogen production was put on a full-scale practical commercial basis last year. (Air Products engineers built and began operating a 3-5 million lb./yr. liquid H_2 plant at West Palm Beach, Fla., for the Air Force.) This material appears to be the ideal chemical rocket fuel. In combination with appropriate oxidizers, liquid H_2 offers specific impulses upwards of 360 sec. Blocking its use hitherto has been the difficulty of producing it on a large scale and the difficulty of handling it owing to chemical instability. Both problems now have been solved: the first by development of hydrogen turbo-expanders that give better refrigeration than Joule-Thomson expansion alone; the second by large-scale catalytic conversion of H_2 to its more stable para form.

Best of the oxidizers are liquid fluorine and liquid ozone; significant advances have been made with these too. Engineers have made safe transport and storage of large volumes of liquid fluorine a practical reality with the development of such devices as liquid-nitrogen-jacketed containers. But there are toxicity problems remaining with the material that still must be solved. Too, engineers are finding that ozone, usually distressingly explosive, can be made handleable by dissolving as much as 30% in liquid oxygen.

To reduce liquid-handling troubles, rocket engineers are seeking to imitate in liquids many of the virtues of solid materials. For example, Thiokol's Reaction Motors division came up last year with the pre-packaged liquid-propelled Guardian I and II rockets. These fit fuel and oxidizer tanks around the combustion chamber and thrust nozzle in ready-to-launch packages. Another approach: Southwest Research Institute's technique of encapsulating liquids in metal shells. Metal-encased liquid droplets, alternately of fuel and oxidizer, can be handled as a fluidized solid and compacted as a solid mass in a rocket engine.

Monopropellants, too, make liquids over into solid-like systems for handling. They combine both fuel and oxidizer in a single, storable fluid, thus offer rockets as simple and easy to operate as those using solid systems. Wyandotte, among others, is currently testing such a fluid for the Navy.

Because most U. S. space engineering has military applications, rocket engines are needed that fire quickly and reliably, using the simplest of propulsion mechanisms. Here is where solid propellant systems shine. For example, a launching setup for liquid rockets costs upwards of $30 million while a comparable solid-rocket launching silo can be built for around $1 million. Liquid rockets require countdowns measured in hours, while a solid rocket can be fired virtually instantaneously. This explains the quickening trend away from liquid to solid systems, a trend many observers expect to continue in the decade ahead.

To speed this trend, supporters of solid systems are now vigorously tackling the job of raising their specific impulses to compete with liquids. One technique that seems highly promising: adding ultra-fine metal powder—notably aluminum—to solid propellant mixtures. Addition of 10% aluminum powder to polyvinyl chloride-ammonium perchlorate mixture, Atlantic Research has reported, boosts the punch of that solid propellant by as much as 60%.

Engineers also are seeking still better fuel-binder-oxidizer combinations. For oxidizers, they have switched almost entirely from ammonium nitrate to ammonium perchlorate. Now they are beginning to eye lithium and potassium perchlorates, and other more exotic materials. As for fuel-binder materials, engineers are moving away from the usual resins, plastics and rubbers, such as epoxies, phenolics and acrylics, to experiment with newer and more promising materials such as polyurethane, polyethylene, acrylonitrile-butadiene and polysulfides now becoming commercially available.

Their success is well symbolized in the now-operational Navy Polaris. A two-stage, solid-propelled rocket, the Polaris is the first to use solids for intermediate-range ballistic (1,500 mi.) operations. Thus, its specific impulse must be on a par with the best liquid rockets, thanks to a propellant system using polyurethane fuel-binder, ammonium perchlorate oxidizer and aluminum powder for added punch. The backers of solid systems are certain that the Polaris sets the stage for the decline of liquid propellants by demonstrating that solid systems are not limited to small, short-range weapons.

At this stage in the game, the more exotic ultra-energy propellants continue to be little more than dreams of the future. For example, Rocketdyne has a pilot ion-propulsion device in the earliest test stages and Lockheed has a National Aeronautics and Space Administration contract to develop preliminary engineering data for a nuclear-propelled rocket engine. But the engineers working with these systems are convinced that, before the end of the next decade, they will be the basis for the power plants used in the most adventurous of man's space excursions.

Unlike the traditional liquid and solid chemical combustibles, nuclear energy, ion propulsion and free radical reactions promise specific impulses virtually without upper limit. The best chemical-propellant combination, hydrogen and fluorine, can provide top impulses of about 375 sec. But nuclear "burning" of hydrogen would raise that figure over 850 sec.; energy released by combination of free radicals such as methyl (CH_3) or methynyl (CH) could deliver impulses better than 500 sec. The job ahead is to turn these systems into practical engineering realities.

Education Faces Up to '60's Challenge

On engineering education rests much of the job of keeping our system preeminent for the future. This fact is being recognized.

If chemical engineering is to face up to the challenge of the '60's, it must recognize the challenge to engineering education. Many of the problems of chemical engineering education in the '60's are those of education in general: Growing enrollments, shortages of teachers and facilities, need for more financial aid for both the students and the schools. And specifically for engineering students, the pressure for more and better courses—more mathematics, more science, more engineering, more spelling and grammar.

But a deeper issue of the education challenge is one of values. The Rockefeller Report on education states this well:

"Only if we value intellectual excellence shall we have it.

". . . our task is to insure that the individual may be exposed to a context of values in which high performance is encouraged.

"And if (education) is to have vitality, both teachers and students must be infused with values which have shaped the system."

Before detailing examples of some of the concrete challenges, let's examine one aspect of the challenge of values.

To the U. S. Education Mission to the U.S.S.R., one Soviet official remarked, "We believe in a planned society, you in individual initiative. Let time tell." But, as becomes apparent, in this contest between planned economy and individual initiative, it's still a society's values which determine rewards for achievement. In the Soviet Union, the state creates its own values, determines which achievements shall merit the highest rewards.

The Soviets have adopted a capitalistic practice and effectively challenge manpower and achievement by planned rewards of high salaries and commensurate prestige for scientists, engineers and teachers. These seem not to be cause and effect. Part of the Soviet Union's educational tradition has been inherited from western European culture—the respect and prestige accorded to the professor and scholar. Reinforce this with a salary scale that pays the average professor seven to ten times as much as the average skilled worker and you have a highly motivating system of rewards.

Its effectiveness can be judged from one conclusion of the Engineering Education Exchange Mission to the U.S.S.R. regarding American and Russian students.

"The major difference appears to be that the Russian student is motivated to work much harder while in school than the American student. The reason is that the rewards for achieving a diploma, and the penalties for failure to achieve the diploma, are much more significant in Russia than they are in the United States. Thus, they are producing a larger number of comparably trained people."

The challenge of our democracy is to forge values which will motivate our available talent similarly.

Besides the basic challenge of values, what are the other challenges which the '60's hold for engineering education? Probably the chief ones are financial assistance and the pressure for more science and engineering content.

Recent grants indicate that the financial challenge is being taken up. The Ford Foundation has given $19 million to four institutes of Technology and six universities. Of this, $11.2 million is earmarked for improving faculties; the rest is for improving curricula. The U. S. Government recently awarded $9.2 million to 33 colleges and universities to conduct institutes for science and mathematics teachers, mostly of high-school level.

Yet there are indications that qualified students haven't received due attention. A recent study revealed that, for the estimated 3.3 million college students, there was available $125 million in scholarship grants. The study added that this was seriously inadequate to meet the needs of a population that may double campus enrollment by 1970. It estimated that one-third of those at present enrolled needed about $1,000 in aid to get full advantages from higher education.

In a recent survey of performance of its chemical engineering graduates, an industrial company recommended these changes to strengthen the curriculum: reduce time spent on qualitative and quantitative chemistry and engineering drawing; increase time on statistical theory; provide better understanding of how electronic computers can help engineers; integrate more fully the teaching of physical chemistry with the teaching of chemical engineering thermodynamics.

Recent changes in chemistry curricula at Northwestern University and the Massachusetts Institute of Technology show that educators are sensitive to some of these needs. Organic and some physical chemistry precede analytical for better over-all understanding.

The *Journal of Engineering Education* reported early last year that many changes in engineering curricula are in the direction of more mathematics and basic engineering sciences. Nearly 90% of the schools offering PhD degrees reported dropping engineering practice or other technical areas and introducing work in engineering science or analysis and design. The report notes new curricula or options designed to produce graduates who can aid research engineers in solving difficult theoretical problem by use of pure and applied mathematics, statistics and machine computation. This last seems particularly welcome, in view of U. S. educators' favorable reactions to similar courses being developed in the Soviet Union.

In summary, it seems that the broad challenges have been recognized and are being taken up. The '60's will judge whether we have taken them up with enough vigor and determination.

The Challenge of Rising Costs

It is easy to be misled by money labels, if we consider only the number of dollars or rubles that a workman—or, for that matter, an engineer—must give up for a pair of shoes, or a washing machine, or a mink coat. The true test, of course, is the number of hours he must work to earn the mink coat. By this test, U. S. costs have been falling, not rising, since it takes fewer hours than formerly to earn what he needs; falling especially in comparison with Russia where, for most commodities, vastly more hours of work are still needed to earn a comparable commodity.

So, our expression "rising costs" applies primarily to the short term, before improved technology can raise productivity to the point where real cost again becomes less than before in terms of hours worked. Such a rising cost can come from any of many causes: higher costs for materials, a bigger share for labor's wages, or a larger share for government, in taxes. It can put a marginal producer out of business or force an efficient producer to pass a dividend. So, though rising costs is a transient effect for the long pull, it can be most painful while it is occurring.

The engineer in management must be concerned primarily with the efficient over-all conduct of the enterprise. Other engineers will be concerned with selecting the best methods, materials, designs and techniques. Standards developed by engineers can save costs. Better methods of storing and recovering stored information can eliminate duplicated effort. Costs for research, for obsolescence, for labor which might better be mechanized, can be brought under engineering control. Even pollution control, mainly engaged in as a public service, can sometimes be made to yield a profit over and above the intangible of public good will.

A Must: Better Information Retrieval

If engineers are to become more efficient, one need is to be able to find what's gone before. Mechanized searching's now a must.

In the world of engineering, the price of ignorance is technological surprise. With the acceleration of engineering development in the '60's, chemical engineers will become more and more concerned with this threat. Engineers must exercise particular care to avoid these traps:

- Not knowing what one ought to know.
- Not being able to recall what one once knew.
- Starting a project already completed elsewhere.
- Repeating work already in the public domain.
- Knowing less about a given subject than the organized intelligence network of your competitor.

Here's how James R. Killian, Jr., former special assistant to the President for science and technology, sums up this challenge.

"Currently there are some 55,000 journals containing articles of significance for some branch of research or engineering in the physical or life sciences. More than 60,000 books are published annually in these fields, while approximately 100,000 research reports remain outside the normal channels.

"The problem is further complicated by the fact that a large and important proportion of the world's scientific literature appears in languages unknown to the majority of Americans.

"Russian-language publications now account for a tenth or more of the scientific literature published in the world. We must now anticipate a growing volume of publication in Communist China."

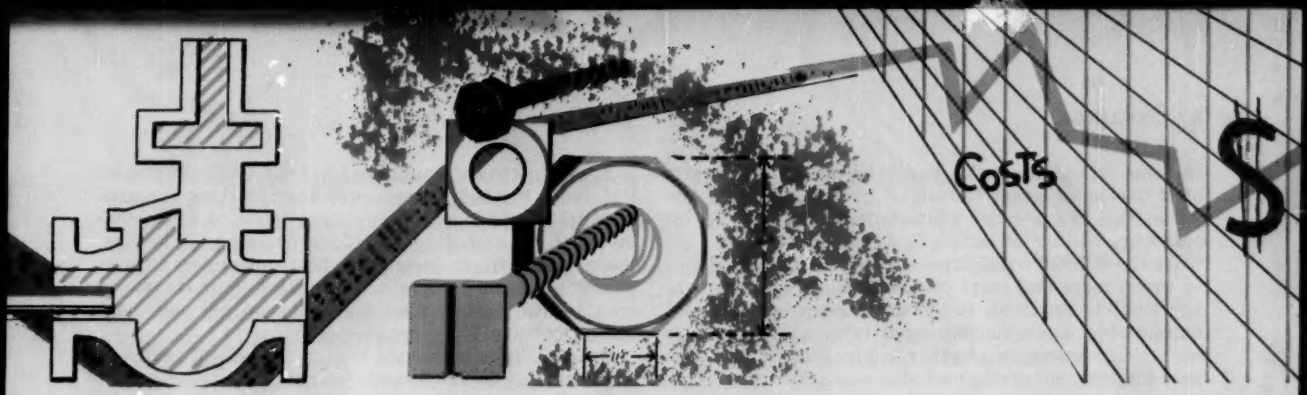
Others have commented on the huge task force of literature scientists that the Soviet Union has assigned to its information retrieval center, known as the All-Union Institute for Scientific and Technical Information of the U. S. S. R. Academy of Sciences (VINITI). Principal function of this organization is to burrow through technical documents and publications from every part of the world, extracting information requested by research and development laboratories throughout the Soviet Union.

VINITI's translation problem is minimized by the fact that about half of all Russian scientists and engineers have been trained to read English. On the other hand, only about 0.1% of American scientists and engineers can read the Russian language.

In the years ahead, to avoid the possibility of technological surprise, engineers and the users of engineering services will have to spend more and more effort and money to transform accumulated corporate intelligence into forms that are amenable to storage and instantaneous retrieval.

More and more chemical engineers will be asked to leave their profession to enter a new branch of engineering. They will be converted into "literature scientists" and "information engineers."

At a recent conference on information retrieval sponsored by IBM, these employers of chemical engi-



neers were among those who reported on their progress in the field: Abbott Laboratories, American Cyanamid, AEC, Dow, DuPont, General Electric, Humble Oil & Refining, M. W. Kellogg, Linde, Merck, Minnesota Mining, Monsanto, National Bureau of Standards, Union Carbide Chemicals, U. S. Patent Office.

Technical information divisions have been formed at the corporate level by some companies to ensure the proper flow of intelligence within their organizations. Typical examples will be found at Esso Research & Engineering Co. and Standard Oil of California.

Also, by direction of the President, the National Science Foundation has the responsibility for taking leadership in bringing about effective coordination of governmental scientific information activities.

The Dept. of Commerce, through the National Bureau of Standards and the U. S. Patent Office has been very active in developing information programs with and for government and private agencies.

The National Science Foundation has also established an information service for all non-government organizations interested in information retrieval.

Several of the government programs include:

• Operation HAYSTAQ. This project (named as it is because of its similarity to the proverbial "like looking for a needle in a . . .") is a cooperative effort by the Patent Office and the National Bureau of Standards to develop an experimental electronic computer program for automatic searching of chemical literature.

• The Air Force project to screen the knowledge of 15,000 top U. S. scientists and engineers in less than a day, using new electronic data processing methods. Principal objective is to locate those who are best qualified to answer the urgent technical questions that are the keys to management decisions. Basis of the system is a standard vocabulary of fixed words and code numbers for use in technical reports submitted to the Air Research & Development Command. Reports written in this standard (rather dull) language can then be indexed, stored and retrieved conveniently.

In the years ahead you'll witness intense concentration on the subject of information retrieval both at home and abroad. Look also for competition among techniques. Electronic data processing of punched cards will be giving way to magnetic tapes. And recent indications are that some of the largest companies in the field are preparing for a big push on the use of microfilm techniques in combination with tapes and electronic punch cards.

Rising Costs Demand Engineer-Managers

Increasingly, as production becomes more technical, managements will be drawn from those technically trained and experienced.

Competent observers of the American industrial scene have predicted that increasing spread of automation during the '60's will result in primarily three kinds of job, and three only, in production, including:

- The machine maintainers.
- The programmers and schedulers.
- The decision-makers.

If we can accept this, it follows that industries of the '60's, increasingly technical and increasingly concerned with cost reduction to offset the many trends toward cost increase, will be forced to turn to managers who have technical training and experience.

In many industries some of the most important decisions require technical information that is only comprehensible to an executive of professional background. For this very reason every company whose product has a high engineering content will have a responsibility—indeed, an absolute need—for developing managers from among its engineering staff.

Nowhere, in recent years, has there been a sharper increase in the demand for engineer-managers than in the U. S. defense effort. Here we have seen the development of the over-all project manager.

The project manager is faced with the task of organizing and controlling intangibles, especially those intangibles that increase the cost of a project. Such a role is basically foreign to an engineer. From his earliest training he has been impressed with the value of scientific analysis. Hard facts are his tools.

Not entirely so, the project manager. Although he must have a thorough professional grasp of the engineering problems involved, he will be concerned with more than technological success. He will be expected constantly to balance engineering solutions against time and cost factors, often making compromises.

Another, more conventional, kind of engineer-manager will become much more numerous in the competitive decade ahead—the manager of other engineers.

From a select group numbering in the thousands, scientists and engineers have spawned into a mass group. Current growth rate is more than eight times that of the labor force generally.

In the decade ahead the number of blue-collar jobs

in some industries will actually be declining in spite of a period of great industrial growth. And at the same time the number of technical jobs will be increasing.

As the number of engineers and scientists continues to grow, more and more cost-conscious engineer-managers will be required. It is a well accepted principle of engineering management that it takes an engineer to be the line manager of other engineers. In fact, the vast majority of engineers today work for other engineers.

Just to give one concrete example, in the electric utility industry today more than half of all members of management were originally trained as engineers.

Then, in production, because of the forthcoming concentration on decision-making and because fierce foreign competition will demand intensive cost reduction, engineers will move up into the ranks of the decision-makers.

The engineer will clearly fit into the over-all pattern of the new top managements. After all, the three main responsibilities of top management are to plan, to operate and to review (or control, if you prefer). The competent technical, professional man—and especially the outstanding engineer—should be better qualified than other types of candidates to step in and fill such top-management responsibilities.

Other trends in engineering management will be worth watching. There has been a feeling prevalent in the decade just past that engineers should stay in engineering and that administrators (perhaps, industrial engineers) should be used to help manage engineering departments.

This feeling is now being reversed by the emergence of capable engineering managers who can administer themselves and their fellow engineers quite satisfactorily without the help of so-called professional administrators. These are the top-flight, capable men who will be called upon to run the cost-conscious companies of the next decade.

In some quarters it is claimed that a final blow to the reign of the business administration clan may well have been spelled out recently in a report said to document the poor quality of business administration graduates. Industry is beginning to realize, it is claimed, that the poorer students slip over to the "B" schools while the really top notch students stay in the engineering schools.

In meeting the challenge of the '60's, engineers will be stepping in ever-increasing numbers into the ranks of top corporate management.

Standards Help Thwart Rising Costs

In the decade ahead standardization, both internal and external, can help to keep down costs. A fair start is already made.

Process industries, in the decade of the '60's, will need every arrow in the cost-reduction quiver if they are to hold the line against the numerous forces of cost increase. Such an arrow is standardization, now used by too few companies outside the mechanical industries.

According to data published in 1958 (ASA Pamphlet PM 163), the lack of standard specifications for centrifugal pumps leads to an annual waste of $6,800,000 in the CPI, excluding petroleum refining. Likewise, the lack of uniform designs for heat exchangers throws $3,900,000 down the drain, while absence of standards on thin-wall carbon steel pipe runs up an additional bill of $2,000,000 per year.

Over-all, it is estimated that the chemical industry could save up to $20,000,000 yearly if it had adequate, uniform standards for most of the equipment it must buy!

Without a doubt then, standardization is one of the most effective leashes on runaway production costs. Standards also can help reduce the price tag for maintenance and assist more efficient utilization of technical manpower.

Chemical engineers can help meet the next decade's challenge of rising costs by initiating, encouraging or participating in standardization programs. There are two routes to these aims—either via active membership on standards committees of professional societies, or through efforts in individual companies.

A professional society, whether it be AIChE, ACS, MCA, or any other, is vitally connected with standardization, both individually and through the American Standards Assn.

ASA, a federation of 120 professional societies and trade associations, is the national clearinghouse for voluntary standards in the United States. Projects of direct concern to the chemical engineering profession, now progressing under ASA's guidance, range from establishment of standards for centrifugal pumps, heat exchangers, compressors, plastic pipe and cooling towers, to standardization of methods for radioactive waste disposal and radiation protection.

Each of these projects has a clearly defined scope that is determined by concensus of all national groups and organizations having interest in the subject.

For example, scope of Project B73, "Centrifugal Pumps for Chemical Industry Use," is given in ASA Bulletin PM 166 as: "The development of standards for horizontal, end suction, single-stage centrifugal pumps, including base plates, suitable for use in the chemical industry, having an approximate capacity range of 5 to 1,000 gpm., for temperatures to 500 F., with discharge heads not exceeding that allowed for American Standard 150 lb. (steel) flanges, and may include any suitable material of construction.

"Consideration may include such items as dimensional interchangeability; features desirable to minimize maintenance, operating and replacement costs; uniform lettering for like dimensions; uniform nomenclature and definitions."

As a matter of interest, the recent progress report for B73 (Sept. 3, 1959) states that much progress has been made toward final project goals. Detailed dimensions have been developed for 13 pump sizes falling into two design categories. However, additional time, effort and patience will be required before all interested parties will approve certain controversial items.

AIChE formed a Standards Committee in 1955. It's purpose, as quoted from Council minutes, is: "To develop standards and codes of importance to the chemical engineering profession and to the chemical industry. It shall confine its activities to the screening, investigation, and development of such standards and

codes that are clearly considered to be chemical engineering and chemical industry standards."

Throughout the chemical process industries, more and more companies are becoming aware of the potential benefits of standardization. For a yearly investment of $150,000 in their "internal" standardization program, Procter & Gamble at Ivorydale, Ohio, typically saves $100,000 through standard tank design, $400,000 through piping.

Another company, in petroleum refining, budgets $29,650 yearly for standardization of materials and equipment used in maintenance and construction. This company estimates direct savings at $40,000.

Perhaps the most extensive and best-known internal standards program under way today is the one in effect throughout DuPont. According to company spokesmen, for every dollar invested in the program, $4 is saved.

Standards at DuPont apply not only to equipment, but also to supplies and buildings. Design, construction, maintenance and procurement methods must all toe the program line.

Actual development of standards, by men in the various manufacturing, engineering and auxiliary departments, would not come to gainful ends without subsequent implementation of the programs by all employees. In all, about 3,000 active standards are in issue; these are well distributed to user employees in about 7,000 standards books.

Based on DuPont's record of success, D. F. Hollingsworth, who heads the standardization operation, lists the following points as a guide to any company or individual contemplating setup of a standards program:

- Establish sound standards that represent best thinking of a wide cross-section of experienced company personnel.
- Keep standards current. Review regularly with all concerned, and eliminate obsolescence.
- Distribute standards widely to all potential users.
- Index standards for quick, easy reference.
- Stress participation and promotion by all employees.

At Houston, Tex., Shell Chemical Corp. is currently reaping benefits from its pump standardization program. Working with United Centrifugal Pumps (Oakland, Calif.), Shell engineers developed the VRO—a vertical centrifugal pump with an integral electric drive.

All VRO's are the same size and design, but each is equipped with an interchangeable venturi discharge orifice. The orifice permits the basic VRO to handle the job of virtually any pump in the size range of ¾ to 3 in. Shell thinks that the VRO can eventually replace 80% of the 650 centrifugal pumps studied.

Design of the pump permits its quick removal from service for shop repairs. Other standard features include construction aimed at quick shop assembly and disassembly, and minimization of the number of component parts.

Plant tests with 16 VRO's, extending from the design's inception in early 1958 to the present, show installed-cost savings ranging to 35%, maintenance savings to 25%. Such performance is possible because, in a concerted effort, company engineers got together and evolved a design that met workable, maintenance-saving standards.

Pollution Control Cost Is Growing

Public demand will increase pollution control costs in the future, requiring more offsetting ingenuity by engineers.

Rising standards in the '60's will inevitably demand more effective industrial pollution control. In the last analysis, of course, the public will pay for it as a component of the cost of the things they buy. But, at least for the short haul, the added cost will accrue to the already heavy price industry pays for the pollution control now in operation.

Most pollution control, unfortunately, requires an outlay with little or no return—except for the intangible one of community good will. Of 175 industrial firms queried some years ago, little more than 2% reported full recovery of the costs of air pollution control, 44% reported partial recovery, 54% no recovery.

The chemical industry sets aside 2.5-5% ($30-60 million/yr.) of its new construction costs for pollution control; at least 1.0-1.5% ($200-250 million) of all production costs for air pollution. Chemical firms buy 20% of all air-pollution-control equipment sold.

Note that these figures do not include research, testing, litigation, lost production through shutdowns, etc. Nor do they include the penalties of switching to more costly, low-sulfur fuels (as petroleum refiners in Los Angeles are required to do) or of changing the olefin content of the product (LA refiners again) or of having to build a plant in a less-than-optimum location.

Doing an even better job of pollution control in the future—without letting already swollen spending get out of hand—is the knotty problem being handed more and more often to chemical engineers, no matter what industry they work in. Here's how they are attacking the problem on some broad fronts.

- Preserve and increase the environment's capacity to assimilate waste. Nearly a dozen Wisconsin pulp mills are using turbines to whip air into oxygen-deficient streams. Significant oxygen uptake more than balances out modest power losses. There's increasing recognition of the problem of "thermal pollution" of waterways; discharge of waste heat to streams decreases oxygen solubility and the ability of the stream to cope with organic pollution. Sherwin Williams adds surfactants to liquid chemical wastes to assist dispersion of air and facilitate oxidation of sodium sulfite to sulfate.
- Never write off a waste as unrecoverable. Air Reduction is turning mountainous piles of calcium hydroxide byproduct into good calcium oxide to feed its acetylene process. Work in Germany indicates that microorganisms, particularly algae, can absorb radioactive salts from contaminated liquors. Philadelphia Reading and General Dynamics are contemplating a $100-million venture to make chemicals from anthracite mining wastes via Lurgi coal gasifiers, U. S. Steel employs the Lurgi wet contact sulfuric acid process to tap low concentrations of H_2S in coke oven gases.
- Look for the simplest effective device. Engineering research at University of Texas indicates that, for locations with mild winters, waste stabilization lagoons can be designed and operated to do the job of a complete biological treatment plant of the trickling-filter or activated-sludge type. However, the "simplest"

method may be a trap. Deep-well disposal of wastes can be a very expensive disposal method, according to one chemical engineering study last year—so costly, in fact, that unless a very high salt concentration is involved, surface disposal is nearly always better.

• Pit one waste against another. General Petroleum scrubs sour gas with waste caustic and sells the resultant sodium sulfide profitably to local paper mills. General Motors uses SO_2-rich flue gases to reduce hexavalent chromium to trivalent chromium, for subsequent removal by precipitation. Eli Lilly runs activated sludge from antibiotics waste treatment against potent chemical wastes, getting a dramatic coagulation of the latter.

• Enlist the community's help. Many plants have found it cheaper to pay municipal disposal systems for secondary waste treatment than to do it themselves. In a reverse arrangement, however, American Cyanamid, at Bound Brook, N. J., performs secondary treatment on domestic sewage from three nearby towns. The high solids content of the sewage and its biological treatment help Cyanamid to deal with its own chemical wastes. And Dow takes all of the town garbage at Midland, Mich., to smooth out the burning cycle in its chemical-waste incinerator.

• Check waste for enrichment in a saleable product. Spencer Chemical's ammonia plant strips argon from nitrogen used to wash impurities from natural gas which has been partially oxidized with oxygen. Argon content of the oxygen feed is 4%; in the nitrogen bottoms it is 14%.

• Consider solids for absorbing gaseous contaminants. U. S. steel adds lime dust to open hearth furnaces, knocking down fluorine as calcium fluoride.

• Consider better but more expensive equipment and materials. They may be less expensive in the long run. Oxidation of wastes with ozone is enjoying sudden acceptance by industry. Boeing uses ozone to oxidize cyanide, Cities Service uses it to wipe out residual phenol content in refinery waste water. U. S. Army Chemical Corps declares, on the basis of limited trials, that "ozonation is the cheapest effective method of sewage disposal." Ozone is even being tried out on stack gases from a pulp-mill sulfate recovery system.

So much for the present. What must chemical engineers come up with in the decade ahead?

• New methods for recovering chemical effluents which are difficult to treat efficiently and completely by scrubbing: e.g., nitrogen oxides.

• New devices for burning odorous gases whose concentrations are too high for economical adsorption and whose fuel values are too low for conventional burning.

• Gas-cleaning filter fabrics effective and long-lived at temperatures of 500-1,000 F.

• Methods for controlling acid mists and complex aerosols of volatile organics.

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Technology Changes the Cost Picture

With a rapidly changing technology, we find unprecedented pressure placed on engineers to meet the economic challenges of the '60's.

If we start from the assumptions made earlier—our standard of living is high and will continue to go higher, population will grow, the work force will have full employment, we will meet growing competition from abroad—our only conclusion is: the economy must expand to meet these changes. And expand is just what it's been doing since World War II with a 3.4% increase in gross national product every year.

Much of this postwar expansion and almost all of the forthcoming growth will be due to a rapidly changing technology—showing also, a remarkably increasing rate of change—the pace quickens.

There's more pressure on technology today than ever before, and technological innovations, brought on by engineers, will have a profound effect on traditional concepts of costs.

We have already learned to operate at less than 100% capacity without alarm—no doubt because of the high degree of obsolescence built into our present plants. This aging before old age is brought on, in part, by industry's willingness to expend great sums on research (over $9 billion in 1959). This indicates more than an interest in improving what we already have; it shows also an eagerness to embark on new and perhaps revolutionary enterprises.

Research brings on change and change brings on obsolescence.

Capital equipment has been added at unprecedented rates since the end of World War II. This increase in capital investment has carried with it an attendant increase in output per manhour, our present definition of productivity. In fact, output per manhour has grown much faster than in previous periods. From 1948 to 1957 the increase averaged 3%/yr. while from 1919 to 1948, only 2.5%/yr.

Labor is aware of this change and has shown a growing interest in introducing these concepts of productivity into collective bargaining. And that's the rub. Productivity is a controversial element, at best, and there will continue to be disputes on how to define it.

By looking a little further into the problem we'll see that while output per manhour has gone up, output per unit of capital investment has actually fallen. Simply, output has failed to grow in step with additions to tangible capital. When we look at overall productivity—productivity of both capital and labor combined—then the annual rate of gain is only about 2.3%. This is still an increase over earlier periods but much less than originally anticipated.

Especially in the chemical process industries, this discrepancy between the productivity of capital and the productivity of manpower will continue to grow. How fast this discrepancy will increase depends on the abilities and ingenuity of the engineers.

These economic changes then fall right back into our laps. As engineers, we are bringing on these changes and must therefore be aware of their implications and meanings—and how best to keep them under control.

Beware Detonations

Unexpected explosions leading to shock-wave phenomena may bypass relief devices and release enormous quantities of energy which shatter process equipment.

DETONATIONS of combustible mixtures in processing equipment have become more frequent in recent years. An examination of the conditions leading to detonative explosions indicates that large modern installations with long pipe runs, large vessels and high velocity vapor lines are more susceptible to detonative explosions than were older smaller installations. However, old process units and small equipment can be subject to detonation.

It is most important that design engineers and operators of plants handling hydrocarbons be fully aware of what detonations are and under what conditions they can occur.

Information given in this article was abstracted from the following papers presented at the annual meeting of the American Petroleum Institute, Division of Refining, Chicago, Nov. 10, 1959.

R. B. Jacobs, "Occurrence and Nature of Hydrocarbon Detonations;" O. A. Pipkin, "Detonation—Old Processes Are Not Immune;" T. L. Smith, "Explosion at the Aberdeen Wind Tunnels Laboratory;" and D. W. Schmitt, "Compressor Test Facility Explosion."

Combustible mixtures may undergo normal explosion or detonative explosion. In normal explosions, it is possible to calculate approximate values for maximum pressure and for destructive energy release by assuming equilibrium conditions, both physical and chemical. In detonative explosions, burning proceeds with such rapidity that there is practically no time for mixing or pressure equalization.

Detonative explosions have three characteristics that make them particularly destructive.

1. Peak pressures may be as much as 20 times the peak pressure produced by normal explosions.

2. Detonation front travels at supersonic speed and thus makes pressure relieving devices useless in most cases. Furthermore, detonations are reflected upon impact with solid surfaces. Such reflections momentarily multiply the pressure in the detonation front by a value of two or more depending upon the angle of impact.

3. Detonation exerts a directed blow rather than a hydrostatic force. This directed blow is often particularly damaging and more destructive than a gradually applied force of the same magnitude.

Detonations create shock waves

What Causes Detonations?

At the present time, there is no exact answer to the causes of detonation. There are two reasons for this:

1. Detonations are a nonequilibrium phenomenon and are somewhat ephemeral in nature. Even under laboratory conditions, it is sometimes difficult to get repeatable results.

2. Not enough is known about detonation, either experimentally or theoretically, to establish with any degree of certainty the conditions under which an explosion may proceed normally or develop into a detonation.

Until recently, it was generally thought that gaseous detonations were largely confined to rapid burning mixtures such as (a) hydrogen

with oxygen or air; (b) unsaturated hydrocarbons with oxygen or air; (c) saturated hydrocarbons with oxygen. In addition, it was known that saturated hydrocarbons and air would detonate if these were in a highly turbulent condition. This knowledge resulted from experimental work following up on a number of pipeline explosions where an unusual degree of violence was exhibited.

Now we believe that almost all flammable gaseous hydrocarbon-air mixtures can detonate. We know further that flammable hydrocarbon mists in air will also detonate, although two or three years ago, lively debates were held on the subject of whether hydrocarbons mists in air were capable of anything more destructive than slow burning.

Because of the great destructive potential of detonations, disasters can be avoided only by carefully guarding against all conditions which can result in the presence of flammable mixtures within operating units. If air or oxygen must be used in the process, its concentration in hydrocarbon mixtures must be known at all times and must be rigorously controlled.

Old Process Are Not Immune

At exactly 6:00 a.m. Jan. 22, 1959, No. 1 Dubbs dephlegmator at the Ponca City, Okla. refinery of Cities Service Oil Co. was ripped by a violent explosion. This unit was one of two units operated by the refinery for over 30 years and was offstream for cleanout operations. The unit had been cleaned and turned over to operations on the evening before. Start up procedure, based on long-established practice, was designed to accomplish three things:

1. Purge air from unit.
2. Permit pressure test for leaking flanges and furnace plugs.
3. Permit check of relief valve operation and set pressure.

Filling process for these Dubbs cokers can be described as follows:

A large-volume, low-head centrifugal pump transfers oil from the startup tank to the bottom of the reaction chambers, while a smaller reciprocating pump charges material through the furnace to the top of the chambers. The material used for filling the unit is a blend of decanted oil and tar, coming from storage at a normal temperature of 200 F. Because of the cold weather, the oil temperature was down to 150 F., making it quite viscous and difficult to transfer.

During the filling operation, the vent line from the top of the dephlegmator is open to allow the air to escape from the unit as the oil displaces it. On this particular night, the evening shift operator failed to open the vent valve when lining up the unit.

In continuing the normal filling procedure, after the two reaction chambers are full, oil overflows through the overhead vapor line into the dephlegmator. When the dephlegmator is full, as observed by an overflow of oil from the vent, the vent valve is closed to build pressure to 225 psi. for pressure test and check of relief valves located on top of the reaction chambers. The relief valves on the chambers also provide relief protection for the dephlegmator since there are no valves in the vapor line between the vessels.

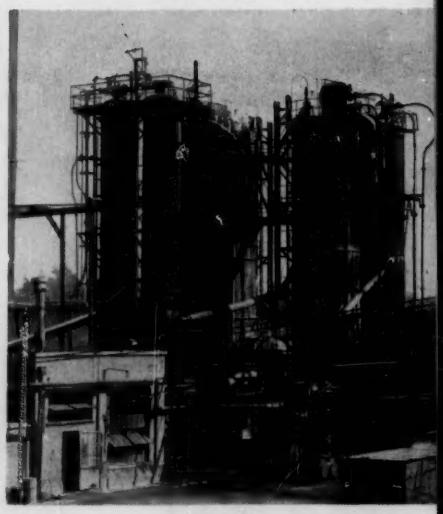
After the pressure test is complete, the hot oil circulating pump is started and furnace fires lighted in preparation for bringing the unit onstream. The filling pump had been started only a short time prior to the arrival of the shift operator at 11:00 p.m.

As is customary, the shift operator proceeded to make a recheck of the unit line-up. This was the start of a series of unfortunate circumstances. The shift operator, probably in haste to get out of the cold, failed to catch the previous operator's mistake. The vent valve remained closed.

Normal filling time of the unit is three to four hours when the charge stock is hot and free of coke particles. Since the unit was filling slowly, the operators attributed it to cold charging stock and possible plugging of the filling-pump suction screen with coke fines. Later the filling pump began to run hot and was shut down. This hot filling pump was a clue which, if grasped, could have brought about a true diagnosis of the trouble. The filling pump had reached its maximum discharge pressure of approximately 90 psig. because of compression of air in the system.

Two things are probably responsible for the operators' failure to catch the true significance of the hot pump:

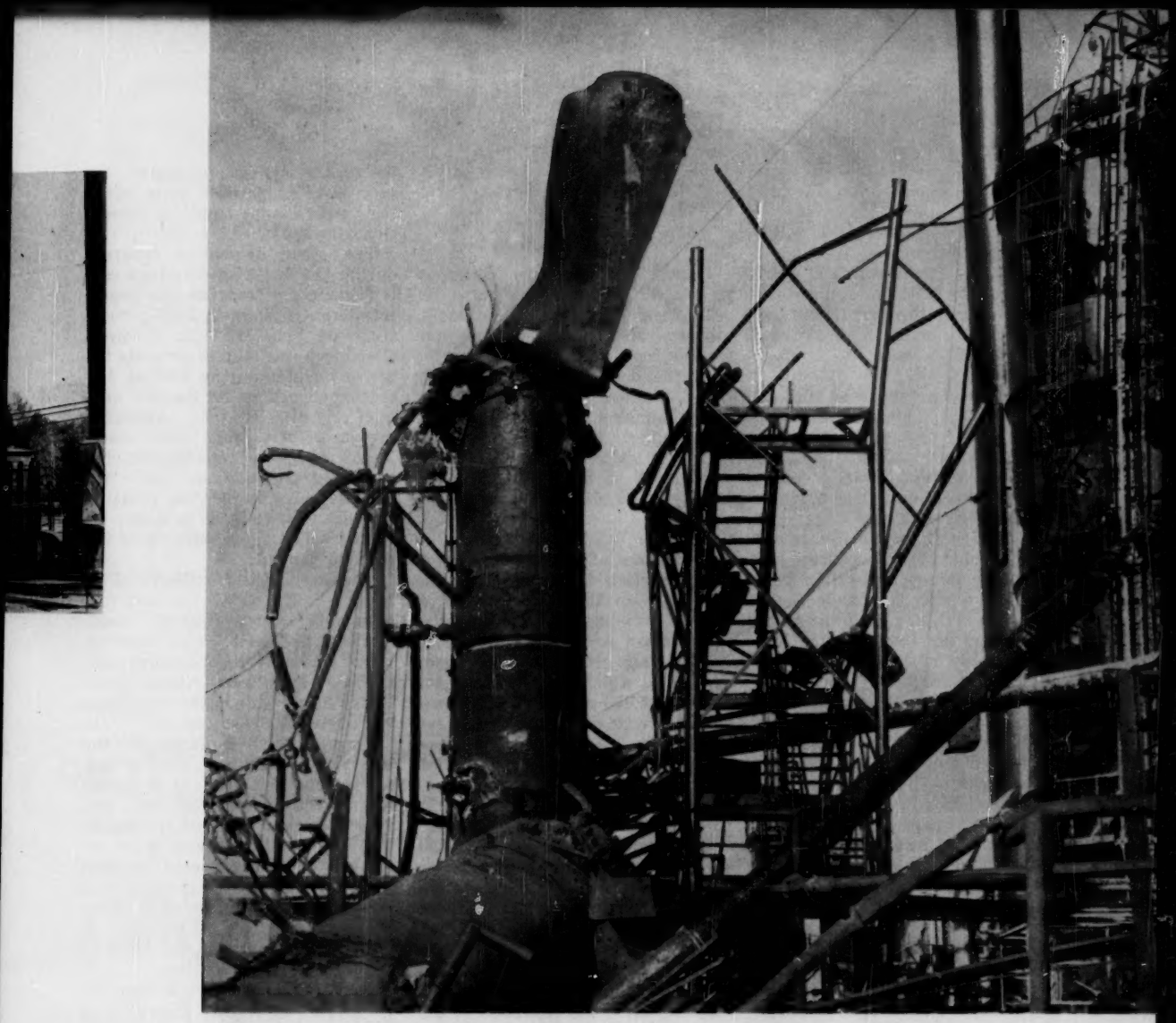
1. Filling time had been long on some recent runs because of plugging of the suction strainer on the filling pump.
2. Pressures recorded on the suction and discharge of the hot circulating pump did not appear to be significantly higher than normal.



. . . and seconds later . . .

After the main filling pump had been shut down, the operators gave conscientious thought to ways of speeding up the filling process. Lighting a fire in the furnace at this stage of startup was not normal. However, this had been done on some occasions, with permission of the unit foreman, when the unit was down for an extended period which allowed the furnace to cool abnormally. This was the first time operators had taken the liberty of lighting the fire without approval of the foreman. In view of the extended unit cleanout time and the low atmospheric temperature, no doubt approval would have been given along with some word of precaution on high oil temperatures if the request had been made.

At 4:30 a.m., pressure upstream of the furnace was 90 psig. and increasing. Charge rate through heater was approximately 800 bbl./day. At 5:30 a.m., an oil level was indicated on the dephlegmator-bottoms level instrument. Pressure was almost 130 psig. but had not yet aroused concern. Furnace transfer



temperature was observed to be 450F.

Instead of reducing furnace firing rate, the operators managed to increase the charge to 1,700 bbl./day which brought the temperature down to 350 F. With increased feed, pressure at the furnace inlet began to increase at the approximate rate of 6 psi./min. Operators attributed this increase to additional pressure drop through furnace tubes. As pressure approached 200 psig., the operators became concerned and activated the coke-chamber pressure gage. This instrument was normally left out of service until after the pressure test to prevent overranging. When they got their check, the worst was confirmed. Pressure at top of coke chamber had reached 200 psig. and still climbing. Pressure at the furnace inlet was now 250 psig.

Now everything was clear, either the vent line was plugged or vent valve was closed. The stillman immediately confirmed that the vent valve was closed. Operator from No. 1 Dubbs unit was sent to the valve at once. Operator from No. 2 Dubbs went along to assist in opening the valve.

They found the valve could not be opened by hand. Operator from No. 2 Dubbs walked around the dephlegmator in search of wrench. Meanwhile, chamber top pressure had reached 250 psig., and furnace inlet pressure was 300 psig. It was too late, No. 1 Dubbs dephlegmator exploded.

Cause of the Explosion

There is now little doubt that the explosion was caused by spontaneous ignition of ram oil vapors in the dephlegmator. Ram oil is a light gas-oil product produced in thermal cracking operation. It is used in small quantities before each startup to flush out valves, drains, level lines and pressure connections in the Dubbs units.

Spontaneous ignition temperatures for ram oil as determined by the Bureau of Mines range from 469 F. to 493 F. at atmospheric pressure and 250 psig., respectively. A conservative estimate of the final gas temperature near the surface of the hot liquid was 500 F. Thus theory seems to verify that suffi-

cient temperature did exist to both vaporize and spontaneously ignite ram oil.

The clean fractures of the dephlegmator fragments, free from any thinning at the points of rupture, indicate without doubt that failure occurred through detonation at pressures much higher than would be experienced with slow combustion.

The cause of an explosion such as this can never be stated with absolute certainty, but the conclusion that it occurred through spontaneous ignition of ram oil vapors seems justified. If the human error, which resulted in the vent valve remaining closed, had been corrected, an explosion would not have occurred because the spontaneous ignition temperature would not have been reached. Further, even if the spontaneous ignition temperature had been reached and the vent valve was open, the magnitude of any explosion would have been greatly reduced because of the smaller quantity of air available for combustion in the dephlegmator.

The hazards of air in refinery processing cannot be overemphasized. In this case of human error which resulted in explosion of the dephlegmator, one cannot help but wonder if the explosion could have been avoided by better training techniques.

Without exception, various operators when questioned knew that it was absolutely essential that the vent valve had to be open to purge air and prevent explosions when the unit was being filled. This experience also reveals that we must beware of the seemingly harmless changes in operating procedure which may grow out of some particular expediency.

As a result of this explosion, we have reviewed our operating procedures on other units and have corrected two unsafe practices which have been in effect for years on the two oldest units in the refinery.

In one case, a stabilizing unit was being purged by displacing air with gas rather than first purging with steam and then breaking with gas. The other case involved a startup procedure on a thermal cracker where air was being displaced with hot vapors generated in the process of circulation.

A process can be immune from detonation but first it must be inoculated with a startup procedure which eliminates the contact of oil with air.

Compressed Air Facilities

Detonations have also occurred in two air compressor plants. In both cases, the air compressors were operated for test purposes on a closed loop.

In the detonation occurring at the Aberdeen Proving Ground Wind Tunnels Laboratory, air from an existing compressor plant at pressures up to 90 psi. was fed to a series of three centrifugal compressors and discharged at 2,250 psia.

On Feb. 10, 1959, after several starts in the afternoon, the explosion occurred. The pipe from the air cooler to the throttling valve burst in two places. The compressor was completely wrecked internally and the air cooler was damaged. The pipe which burst had been tested at 3,450 psi. and had a theoretical bursting strength of at least 15,000 psi. The compressor was being run at a discharge pressure of 750 psi. at the time of the explosion.

Later tests show that the light turbine oil used for lubrication has an auto-ignition temperature at 750 psi. of about 400 F. which was lower than the compressor discharge temperature. Also there was evidence of oil decomposition. It is evident that oil must be kept out of high-pressure air systems as well as out of oxygen lines. The nature of the fragmentation and estimates of the magnitude of the blast effects seem to prove that the damage must have been caused by detonations. Such effects could not have occurred from the release of the compressed air due to pipe failure.

It is believed that ignition occurred in or near the compressor. It could have been caused by rubbing of interstage labyrinth seals, a static discharge spark, or a spark from a dust particle. But no such ignition source is needed as conditions were such that auto-ignition would have been expected.

From the ignition point, we believe a combustion wave moved downstream through the cooler, and continued to the point where a detonation occurred. Such a combustion wave has been shown capable of picking up and burning an oil coating on the pipe wall, gradually building up energy until a detonation occurs. From the spot where the detonation occurs, the process of combustion wave building up to a pipe-bursting detonation can repeat.

The other detonation occurred during the test of a five-stage centrifugal compressor at the Ingersoll-Rand Co. plant in Phillipsburg, N. J. on Feb. 11, 1959. Again a closed loop was used to circulate the gas or air used during the test. Operating conditions for the unit were inlet pressure, 916 psig.; discharge pressure, 1,920 psig.; rated speed, 10,150 rpm.; inlet capacity, 983 cfm.

During adjustment of the throttle valve to increase pressure for one of the tests, an explosion occurred without any warning of impending danger.

The explosion was described as being a heavy blast with flash fire, producing shock waves. Small localized fires and smoke followed. Floor plates of the platform over the test loop were ripped loose. Heavy brick walls in the immediate vicinity were blown out.

The roof of the building over the blast was damaged and moved. Light-weight sidewalls of the building were torn off. Test loop, seal oil system and most of the equipment on the lower level were destroyed. Coupling spaced between the gear and the compressor was shattered. Coupling end of the gear pinion was twisted off and thrown some distance outside the building housing the test facilities.

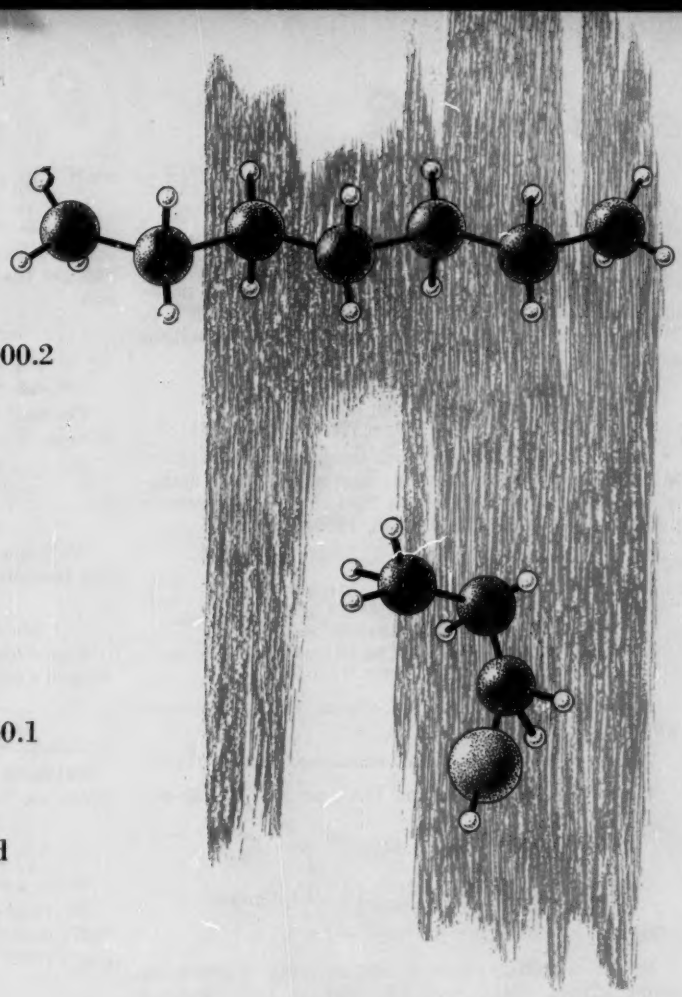
Definite evidence of a combustion-type explosion shows that there must have been enough hydrocarbon oil present within the loop system to produce a combustible oil-air mixture throughout the loop system. Oil had been present when blowing out low points in the piping between test runs. The appearance and condition of the internal parts of the compressor and the location and character of the ruptures in the test loop piping indicate that the start of the combustion explosion was within the compressor rather than at any point in the loop piping.

Two possible causes of ignition are selected as appropriate for the conditions in this test. These are: high temperature or sparks produced by accidental contact and friction between moving parts of the compressor; and heat produced within a gas by compression or by internal work caused by rapid movement and turbulence.

Free—For you files—Check your Reader Service postcard (p. 184) for an extra copy of this article.

Take a typical
Nonpolar Hydrocarbon,

n-Heptane
Molecular wt. = 100.2



. . . or a
Highly Polar Organic,

n-Propyl Alcohol
Molecular wt. = 60.1

. . . With only your slide rule and the methods ★ given here,

Calculate Engineering Properties

WALLACE R. GAMBILL, Union Carbide Nuclear Co., Oak Ridge, Tenn.

THROUGHOUT this article series, which concludes with this installment, we have indicated the degree of accuracy associated with the various engineering property estimation methods.

To more specifically familiarize the reader with the deviations to be expected when you calculate a number of properties of a chemical compound from minimum information, we've made such calculations for two representative compounds. One is a nonpolar hydrocarbon, *n*-heptane; the other is a highly polar organic, *n*-propyl alcohol.

We've assumed that we know only the molecular formulas (therefore, the molecular weights) and normal boiling points: C_7H_{16} (M = 100.2) and 98.4 C. for heptane; and C_3H_7OH (M = 60.1) and 97.3 C. for propanol. We then proceed to estimate a number of pure-component properties and compare these values with experimental data obtained from standard references.

All physical properties—other than those assumed known—which appear as independent variables in the estimation equations are also estimated. Calculations were made with slide rule accuracy, and the error figures were computed as 100 (calculated value minus experimental value)/experimental value.

The parenthetical *Chemical Engineering* references are to past issues in which the estimation methods used here were described. For symbol notation, refer to the original articles.

★ Methods are those covered in this 3-year series of articles. See p. 111 for a tabulation of the articles, the dates of publication and information about reprint availability.

Calculations for Heptane Properties

For the *critical temperature*, we use Eduljee's method (*Chem. Eng.*, June 15, 1959, p. 181).

$$T_b/T_c = \Sigma\Delta_T/100$$
$$\Sigma\Delta_T = (7)(-55.32) + (16)(28.52) = 68.0$$
$$\therefore T_c = T_b/0.68 = 371.6/0.68 = 545.5 \text{ K.}$$
$$(T_c)_{expti.} = 540.2 \text{ K.;} \quad \text{error} = 0.98\%$$

We also use Eduljee's method for the *critical pressure* (*Chem. Eng.*, July 13, 1959, p. 157).

$$p_c = 10^4 M/(\Sigma\Delta_p)^2$$
$$\Sigma\Delta_p = (7)(-9.35) + (16)(16.20) = 192.3$$
$$\therefore p_c = (100.2 \times 10^4)/(192.3)^2 = 27.1 \text{ atm. abs.}$$
$$(p_c)_{expti.} = 27.01 \text{ atm. abs.;} \quad \text{error} = 0.33\%$$

For critical volume we use Lydersen's method (*Chem. Eng.*, July 13, 1959, p. 157).

$$V_c = \Sigma\Delta_V = 40 + (7)(55) = 425 \text{ cc./gram-mole}$$
$$(V_c)_{exptl.} = 426 \text{ cc./gram-mole; error} = -0.23\%$$

For use in later calculations, we evaluate the *parachor* and *molar refraction* (*Chem. Eng.*, July 1957, p. 263); and the *molecular volume* at the normal boiling point, T_b (*Chem. Eng.*, April 7, 1958, p. 146).

$$[P] = (7)(40.0) + (2)(15.4) = 310.8$$
$$[R_D] = (7)(4.618) + (2)(1.100) = 34.53$$
$$V_b = (7)(14.8) + (16)(3.7) = 162.8 \text{ cc./gram-mole}$$

At the normal boiling point, *liquid density* is calculated using Benson's method; and at 20 C. by extrapolation from the density at T_b using Goldhammer's equation (*Chem. Eng.*, Nov. 16, 1959, p. 193).

$$\rho_b = \rho_c(1.981 + 0.422 \log p_c)$$
$$\rho_c = 1/V_c$$
$$= \frac{\text{gram-mole}}{425 \text{ cc.}} \times \frac{100.2 \text{ grams}}{\text{gram-mole}} = 0.236 \text{ grams/cc.}$$
$$\therefore \rho_b = 0.236(1.981 + 0.422 \log 27.1) = 0.611 \text{ grams/cc.}$$
$$(\rho_b)_{exptl.} = 0.618 \text{ grams/cc.; error} = -1.13\%$$

Note that the molecular volume evaluated above gives:

$$\rho_b = 100.2/162.8 = 0.617 \text{ grams/cc; error} = -0.16\%$$

To get the liquid density at 20 C., proceed as follows:

$$\rho_{20} = \rho_b\left(\frac{T_c - T_{20}}{T_c - T_b}\right)^{1/3}$$
$$\rho_{20} = 0.611\left(\frac{545.5 - 293.2}{545.5 - 371.6}\right)^{1/3} = 0.695 \text{ grams/cc.}$$
$$(\rho_{20})_{exptl.} = 0.685 \text{ grams/cc.; error} = 1.46\%$$

By extrapolating ρ to 60 F. and by using the pressure chart (*Chem. Eng.*, Nov. 16, 1959, p. 193), we can estimate ρ at 60 F. and 50,000 psi. to be 0.699 + 0.135 = 0.834 grams/cc. This is a 19% increase over ρ at 1 atm.

To calculate *surface tension* at 20 C., we use Sugden's equation (*Chem. Eng.*, April 7, 1958, p. 146).

$$\sigma = ([P]\rho_L/M)^4, \text{ neglecting vapor density}$$
$$\therefore \sigma = [(310.8)(0.695)/100.2]^4 = 22.0 \text{ dynes/cm.}$$
$$\sigma_{exptl.} = 20.3 \text{ dynes/cm.; error} = 8.37\%$$

The Lorentz-Lorenz equation (*Chem. Eng.*, Dec. 14, 1959, p. 169) gives the *refractive index* at 20 C.

$$n = \left(\frac{2[R_D] + V}{V - [R_D]}\right)^{1/2}$$
$$= \left[\frac{(2)(34.53) + (100.2/0.695)}{(100.2/0.695) - 34.53}\right]^{1/2} = 1.276$$
$$n_{exptl.} = 1.388; \text{ error} = -8.07\%$$

For *latent heat of vaporization* at T_b, the Klein-Kharbanda method (*Chem. Eng.*, Dec. 1957, p. 261) is used.

$$L_V = 4.576T \log p_r \Delta z/(T_r - 1)$$
$$p_r = 1.0/27.1 = 0.0369; \quad T_r = 371.6/545.5 = 0.68$$
$$\Delta z = [1 - (p_r/T_r^2)]^{1/2} = [1 - (0.0369/0.3142)]^{1/2} = 0.94$$
$$\therefore L_V = (4.576)(371.6)(\log 0.0369)(0.94)/(-0.32)$$
$$L_V = 7{,}155 \text{ cal./gram-mole} = 128.5 \text{ Btu./lb.}$$
$$(L_V)_{exptl.} = 7{,}580 \text{ cal./gram-mole; error} = -5.6\%$$

From the chart for hydrocarbons (*Chem. Eng.*, Feb. 10, 1958, p. 139), L_V = 135 Btu./lb. = 7,520 cal./gram-mole; error = − 0.79%.

Liquid specific heat at 20 C. is calculated from the Johnson-Huang method (*Chem. Eng.*, Dec. 14, 1959, p. 169).

$$c_P = (5)(6.3) + (2)(9.9) = 51.3 \text{ cal./(gram-mole)(°C.)}$$
$$c_P = 0.510 \text{ Btu./(lb.)(°F.)}$$
$$(c_P)_{exptl.} = 0.526; \text{ error} = -3.04\%$$

From Table I of *Chem Eng.*, June 1957, p. 243, we can get the *vapor specific heat* at 1,000 K. and 1 atm. abs.

$$c_P = 4.0 + 1.3n + 0.012nT$$
$$\therefore c_P = [4.0 + (1.3)(7) + (0.012)(7)(1{,}000)]/100.2$$
$$c_P = 0.967 \text{ Btu./(lb.)(°F.)}$$
$$(c_P)_{exptl.} = 0.910 \text{ Btu./(lb.)(°F.); error} = 6.26\%$$

Thomas' method gives *liquid viscosity at* 100 C. (*Chem. Eng.*, Jan. 12, 1959, p. 127).

$$\mu_L = 0.1167\rho_L^{1/3}10^{\alpha}, \text{ where } \alpha = B(1 - T_r)/T_r$$
$$B = (7)(-0.462) + (16)(0.249) = 0.742$$
$$T_r = 373/545.5 = 0.683$$
$$\alpha = 0.742(1 - 0.683)/0.683 = 0.345$$

We'll use ρ at T_b from our calculation above, since the temperature here is only 1.6 deg. C. greater.

$$\mu_L = 0.1167(10)^{0.345}(0.611)^{1/3} = 0.202 \text{ cp.}$$
$$(\mu_L)_{exptl.} = 0.209 \text{ cp.; error} = -3.35\%$$

Vapor viscosity at 200 C. and 1 atm. abs. comes from Arnold's equation (*Chem. Eng.*, Sept. 22, 1958, p. 169).

$$\mu_g = 27.0M^{1/2}T^{1/2}/V_b^{2/3}(T + 1.47T_b)$$
$$\mu_g = (27.0)(10.01)(10{,}500)/(30)(1{,}018) = 0.0093 \text{ cp.}$$
$$(\mu_g)_{exptl.} = 0.0098 \text{ cp.; error} = -5.10\%$$

Palmer's method (*Chem. Eng.*, Feb. 1957, p. 237) gives the *liquid thermal conductivity* at 20 C.

$$k_L = 41.2c_P(\rho/M)^{1.33}(T_b/L_{Tb})$$
$$\therefore k_L = (41.2)(0.510)(0.695/100.2)^{1.33}(371.6/128.5)$$
$$k_L = 0.082 \text{ Btu./(hr.)(ft.)(°F.)}$$
$$(k_L)_{exptl.} = 0.074; \text{ error} = 10.8\%$$

Thermal conductivity of the vapor comes from Maxwell's equation including the Eucken correction (*Chem. Eng.*, April 1957, p. 277).

$$k_g = \mu[c_P + (2.48/M)]$$

Recalculating c_P for 200 C. and 1 atm. abs. using the same method as that described under vapor specific heat,

$$c_P = [4.0 + 9.1 + (0.012)(7)(473)]/100.2 = 0.525$$
$$\therefore k_g = (0.0093)(2.42)[0.525 + (2.48/100.2)]$$
$$k_g = 0.0124 \text{ Btu./(hr.)(ft.)(°F)}$$

An experimental value of k_g for heptane at these conditions doesn't appear to be readily available. This is also true for Prandtl number and compressibility factor, which we may estimate as follows:

Prandtl number of the vapor at low pressure comes via the method of group averages (*Chem. Eng.*, Aug. 25, 1958, p. 121). Since the *n*-heptane molecule is the linear nonpolar type, $N_{Pr} \approx 0.73$.

Vapor compressibility at 200 C. and 1 atm. abs. is taken from the Pitzer-Edmister charts (*Chem. Eng.*, Oct. 19, 1959, p. 195).

$$z = z^0 + \omega z'$$
$$\omega = 0.425\left[\frac{\log p_c}{(T_c/T_b) - 1}\right] - 1$$
$$= 0.425\left(\frac{1.432}{0.471}\right) - 1 = 0.291$$
$$T_r = 473/545.5 = 0.865; \quad p_r = 1/27.1 = 0.0369$$
$$z^0 = 0.978, \quad z' \approx -0.01 \text{ (from charts)}$$
$$\therefore z = 0.978 + (0.291)(-0.01) = 0.975$$

We Could Have Started With Less

It's worth noting that a fair estimate of the normal boiling point could have been made by using the

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Meissner equation (*Chem. Eng.*, Oct. 19, 1959, p. 195), if T_b had not been available.

$$T_b = \frac{637[R_D]^{1.47} + B}{[P]} = \frac{(637)(34.53)^{1.47} - 2{,}500}{310.8}$$

$T_b = 365\text{K.}$; error $= -1.78\%$

The accuracy of the engineering properties that we have now calculated for *n*-heptane would certainly be adequate for almost all engineering applications. In practice, of course, physical properties would usually be estimated for a number of temperatures, for pressures other than 1 atm., and for mixtures of the pure component with other compounds.

You should also recognize that the selection of estimation methods and their sequence in the calculation scheme will vary with the experimental data initially available.

Calculations for Propanol Properties

Because of its large polarity, *n*-propyl alcohol should afford a more severe test of the correlations. Note

that references for methods will be given below only if they differ from those already given.

Critical temperature, Eduljee's method:

$$\Sigma\Delta_T = (3)(-55.32) + (7)(28.52) + (1)(35.62) = 69.2$$
$$\therefore T_c = T_b/0.692 = 370.5/0.692 = 535\text{K.}$$
$$(T_c)_{exptl.} = 537\text{K.};\ \text{error} = -0.37\%$$

Critical pressure, Eduljee's method:

$$p_c = (60.1)(10^4)/(108.85)^2 = 50.8\ \text{atm. abs.}$$
$$(p_c)_{exptl.} = 50.2\ \text{atm. abs.};\ \text{error} = 1.19\%$$

Critical volume, Lydersen method:

$$V_c = \Sigma\Delta_V = 40 + (3)(55) + (1)(18) = 223.0\ \text{cc./gram-mole}$$
$$(V_c)_{exptl.} = 219.8\ \text{cc./gram-mole};\ \text{error} = 1.46\%$$

Evaluation of *parachor*, *rheochor*, and *molecular volume* at the normal boiling point:

$$[P] = (3)(9.2) + (1)(10) + (7)(15.4) + (1)(20) = 165.4$$
$$[R_D] = (3)(2.418) + (8)(1.100) + (1)(1.525) = 17.58$$
$$V_b = (3)(14.8) + (8)(3.7) + (1)(7.4) = 81.4\ \text{cc./gram-mole}$$

Alternatively, the parachor may be evaluated with McGowan's constants (*Chem. Eng.*, Dec. 14, 1959, p. 169). This leads to an answer that is 1.37% larger than that given above.

Liquid density at T_b, Benson's method; and at 20 C. by extrapolation from T_b, Goldhammer's equation:

$$\rho_b = \rho_c(1.981 + 0.422 \log p_c)$$
$$\rho_c = 1/V_c = 0.270\ \text{grams/cc.}$$
$$\therefore \rho_b = 0.270(1.981 + 0.422 \log 50.8) = 0.730\ \text{grams/cc.}$$
$$(\rho_b)_{exptl.} = 0.735;\ \text{error} = -0.68\%$$

Note that the molecular volume evaluated above gives a value of 0.7395 grams/cc., or an error of 0.61%.

$$\rho_{20} = \rho_b\left(\frac{T_c - T_{20}}{T_c - T_b}\right)^{1/3} = 0.730\left(\frac{535 - 293.2}{535 - 370.5}\right)^{1/3}$$
$$\rho_{20} = 0.829\ \text{grams/cc.}$$
$$(\rho_{20})_{exptl.} = 0.805;\ \text{error} = 2.98\%$$

Alternatively, the liquid density at 20 C. could have been estimated with the Guggenheim equation (*Chem. Eng.*, Nov. 16, 1959, p. 193). This would have led to:

$$\rho_{20} = 0.725\ \text{grams/cc.};\ \text{error} = -9.94\%$$

(Note: In the original article *reduced* liquid density appeared erroneously as liquid density.)

Somewhat better accuracy is obtainable by using Riedel's proposals for the equation constants. Then we would have obtained this answer:

$$\rho_{20} = 0.855\ \text{grams/cc.};\ \text{error} = 6.21\%$$

For *surface tension* at 20 C., use Sugden's equation, neglecting ρ_r,

$$\sigma = \left(\frac{[P]\rho_L}{M}\right)^4 = \left[\frac{(165.4)(0.829)}{60.1}\right]^4 = 27.0\ \text{dynes/cm.}$$
$$\sigma_{exptl.} = 23.80\ \text{dynes/cm.};\ \text{error} = 13.43\%$$

Refractive index at 20 C., Lorentz-Lorenz equation:

$$n = \left(\frac{2[R_D] + V}{V - [R_D]}\right)^{1/2} = \left(\frac{(2)(17.58)(60.1/0.829)}{(60.1/0.829) - 17.58}\right)^{1/2}$$
$$n = 1.398;\ n_{exptl.} = 1.385;\ \text{error} = 0.94\%$$

If the surface tension is recalculated using the Tripathi equation (*Chem. Eng.*, April 7, 1958, p. 146), with the refractive index calculated above, we get:

$$\sigma = 26.97\ \text{dynes/cm.};\ \text{error} = 13.31\%$$

Latent heat of vaporization at T_b, Klein-Kharbanda method:

$$L_V = 4.576(370.5)(\log 0.0197)(0.97)/(-0.306)$$
$$L_V = 9{,}200\ \text{cal./gram-mole} = 275.5\ \text{Btu./lb.}$$
$$(L_V)_{exptl.} = 9{,}900\ \text{cal./gram-mole};\ \text{error} = -7.1\%$$

Liquid specific heat at 20 C., Johnson-Huang method:

$$c_P = 9.9 + (2)(6.3) + (1)(11.0) = 33.5\ \text{cal./(gram-mole)(°C}$$
$$= 0.556\ \text{Btu./(lb.)(°F.)}$$
$$(c_P)_{exptl.} = 0.563\ \text{Btu./(lb.)(°F.)};\ \text{error} = -1.24\%$$

To illustrate the method, we've calculated the c_P of *n*-propanol at 50 C. also, with the Chow-Bright temperature function (*Chem. Eng.*, July 1957, p. 263).

This gives a value of $c_P = 0.610$; $(c_p)_{exptl.} = 0.655$; error = − 6.87%.

Vapor specific heat at 1,000 K. and 1 atm. abs., method of Stull and Mayfield (*Chem. Eng.*, Sept. 1957, p. 267):

Our calculated value is 0.784 Btu./(lb.)(°F.), giving an error of 0.13%.

Other properties are calculated as indicated below:

Liquid viscosity at T_b, Rheochor method, 0.4605 cp.; error = 0.99%.

Vapor viscosity at 200 C. and 1 atm. abs., Arnold's method, 0.0115 cp.; error = −7.25%.

Thermal conductivity of the *liquid* at 50 C., Palmer's method, 0.1050 Btu./(hr.)(ft.)(°F.); error = 17.47%.

Thermal conductivity of *vapor* at 129 C. and 1 atm. abs., Maxwell equation with Eucken correction, 0.0115 Btu./(hr.)(ft.)(°F.); error = − 16.07%.

Prandtl number of vapor at 129 C. and low pressure, method of group averages, 0.86; error = 2.50%.

Vapor compressibility at 200 C. and 15 atm. abs., Pitzer-Edmister charts, 0.794.

How Did We Make Out?

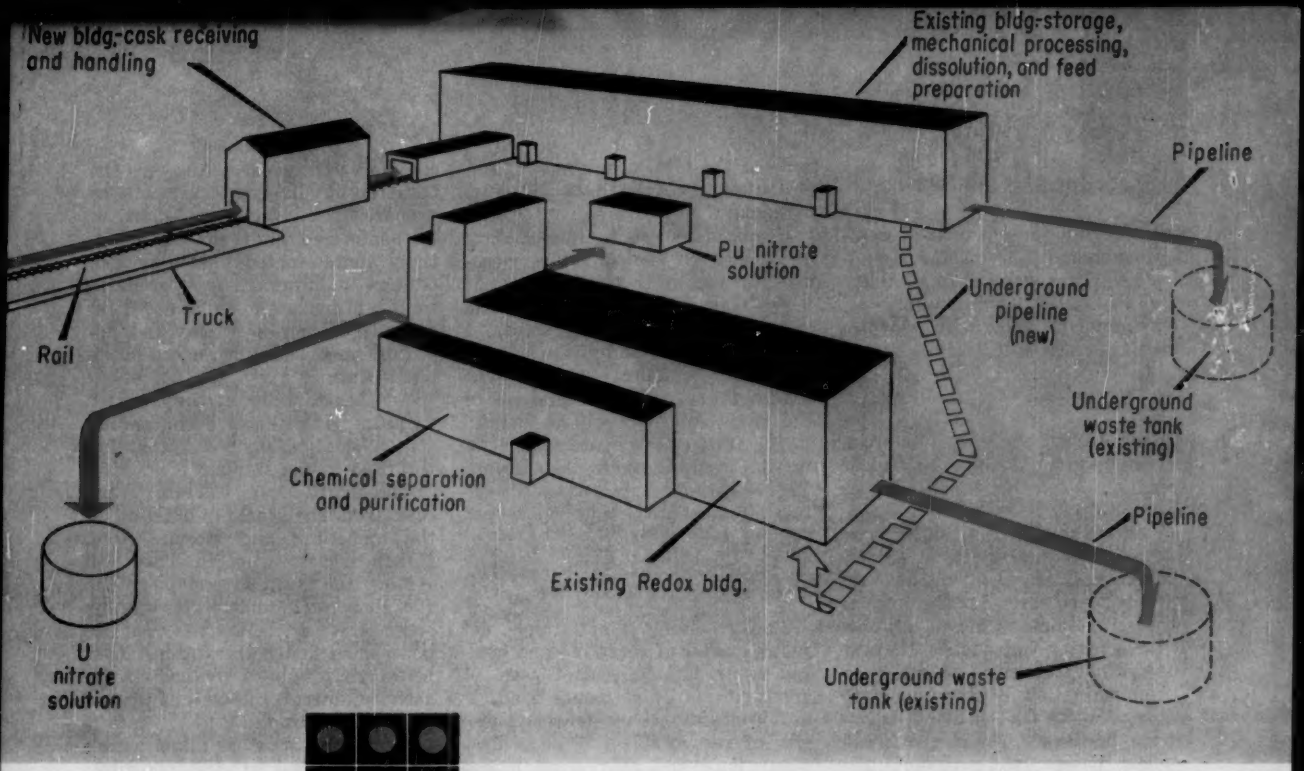
Our results for *n*-propanol (4.9% avg. & 17.5% max. deviations) turned out almost as well as those for *n*-heptane (4.2% avg. & 10.8% max. deviations). The deviations would have been generally smaller if more data had been available initially.

Meet Your Author

WALLACE R. GAMBILL is the author of these pioneering articles that have collected in one place for the first time a wealth of engineering information on the estimation of physical properties, with an accompanying critical evaluation. This series was begun in our Feb. 1957 issue, and in 1958 it won an *Industrial Marketing* Award of Merit for editorial excellence.

At the present time Wally Gambill is employed by Union Carbide Nuclear Co. at Oak Ridge, Tenn. His most recent project has resulted in an important breakthrough in vortex cooling, which may be applied to nuclear reactors. Final reports on this work are now being prepared for publication.

Your author is a graduate in chemical engineering from Georgia Tech (1952) and has been employed by Union Carbide Chemicals Co. in Charleston, W. Va. and UCNC in Oak Ridge. We of *Chemical Engineering* have been privileged to work with Wally and to have had the opportunity of meeting his charming wife Pat and the two lovely Gambill daughters, Linda and Eve.



Atomic Fuel Processing: Part II

HANFORD: Atoms for Peace

A major producer of atomic weapons material turns its talents to the assistance of the civilian nuclear power program.

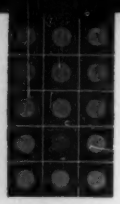
OUT in the wilds of Washington, near Richland, a tall, thin stack reaches 200 ft. to the sky. This stack is one of several that mark the location of the AEC's Hanford works, where uranium is converted to plutonium for nuclear weapons. The plant, though owned by the AEC, is operated by General Electric.

Chemical engineers would find much to interest them at Hanford. Though conversion of uranium to plutonium is a nuclear process, the separation of plutonium from "unburnt" uranium and other fission products is a chemical process. Much of Hanford is a chemical plant having extensive facilities for chemical separation and purification of nuclear materials.

Only a fraction of the fuel charged to a nuclear reactor is burned, whether it is a civilian power reactor or an AEC production reactor. At periodic intervals, the depleted fuel must be removed from the reactor, separated from the inert cladding and radioactive fission products, purified, re-enriched and refabricated into new fuel elements. The facilities at Hanford process fuel for the production reactors and will process fuel for the civilian reactors. However, Hanford will not produce power fuel elements, only decontaminated uranium and plutonium products which are converted elsewhere into the finished materials.

In our first article of this series (*Chem. Eng.*, Dec. 28, pp. 61-66) we discussed the objectives and scope of the AEC's processing program. In this article we will be more specific. We will discuss in some detail fuel processing as it will be done at Hanford.

Work to be done at Hanford, or any of the other processing sites, can be divided into three phases:



fuel receiving, mechanical processing and chemical processing. In addition to these there is an auxiliary service called "measurements." Measurements deals with accountability of nuclear materials.

Measurements

Because of the high cost and dangerous nature of these materials, accurate accounting for them through every step of the processing is of the utmost importance. Sampling and analysis of process streams is an essential part of every chemical process. But in nuclear processing, measurements assumes a far greater importance than in the ordinary chemical plant.

Determination of the monetary value of spent fuel elements is one of the key areas of concern in the nuclear power fuel program. For instance, the spent reactor charges slated for processing at Hanford, though relatively low in uranium enrichment, will contain uranium and plutonium with assessed values of from $500,000 to several million dollars per charge. Therefore a small uncertainty in the measurement of the fissile material content may represent an over or under payment of many thousands of dollars.

The AEC, which during the foreseeable future will be the purchaser of the plutonium and uranium in spent fuels, has always insisted on receiver measurements as the basis for payment to the seller. The seller, of course, will be completely happy with the receiver, i.e., AEC, measurements only if these measurements agree with his own estimates. The problem is further complicated, or simplified, by the presence of a third party, the fuel element fabricator.

The measurements cycle originates with the fuel element fabricator, who has the opportunity to get an accurate value for the composition of his product. The next measurements responsibility lies with the reactor operator. Accuracy of his measurements of reactor power levels, fuel rod exposure and various reactor parameters will determine the accuracy of his calculations of U^{235} burn-out and plutonium production. His calculations will serve as the basis for his estimate of the total uranium, U^{235} and plutonium delivered to the fuel processor.

Uranium and plutonium content of the spent fuels cannot be measured by non-destructive means. It is necessary to dissolve the material and assay the resulting solutions for uranium and plutonium as with any other chemical process. The data obtained from the analyses of the metal solutions will be helpful in the future to the reactor operators in refining their calculations. This will lead to greater accord between calculated and measured values.

Fuel Receiving and Storage

Fuel receiving is not simple, not just a matter of receiving and holding an irradiated reactor core. A spent core is by no means dead. It still contains a considerable quantity of recoverable fuel as well as many long and short-lived fission products formed during critical operation. Though the fuel assembly is not critical when received at the processing plant, critical in the sense of containing a sustained nuclear reaction, it is "hot" in both senses of the word. The fuel assembly is highly radioactive and at a high temperature from radioactive decay heat. Obviously, so dangerous an object must require some very special shipping and handling facilities and techniques.

When a core is removed from a reactor, it is put into a shipping cask. (This operation itself requires some very refined handling procedures to prevent contamination of the reactor area.) These casks are shipping containers, weighing as much as 75 tons each, specially designed for reactor cores. The casks are tailored to the type of core, mode of conveyance (rail, truck or barge) and to the facilities at the processing site. A cask for one type of core assigned to one site is not generally suitable to another type of core assigned to another site.

Irradiated cores will arrive at Hanford in casks aboard special railroad flat cars or trucks. The railroad car or truck arrives at a new building, yet to be built, called the transfer building where the cask is transferred from the cross-country vehicle to a shuttle car. This procedure keeps the cross-country vehicle out of potentially contaminated areas. Also in the transfer building, the cask will be prepared for remote operations to be performed later in the potentially contaminated unloading and storage building. These preparations will include installation of remote type nozzles, valves and operators essential for remote crane manipulation.

Another function of the transfer building is low-level decontamination of empty casks before they are returned to the shipper.

The shuttle car will carry the cask from the transfer building to the unloading and storage area. Here a remote operated crane will remove the cask lid and place the fuel elements in underwater storage cells. However, before the cask can be opened, many precautions must be taken to guard against radioactivity, energy release and spread of contamination.

Typical of the steps taken before opening the cask are the following:

Any pressure present in the cask will be vented to a closed vent system. The vent system will decontaminate the off gas stream before discharge to the main ventilation air stream.

The cask interior will be thoroughly flushed to remove any radioactive contamination that may be present. Excessive radioactivity in the effluent stream would indicate uncontained, ruptured fuel elements in the cask.

If required to prevent thermal shock of the fuel elements upon immersion in the storage cell water, cooling media will be circulated through the cask. Depending on the temperature of the elements, steam, air and water will be the cooling medium.

Fig. 1 is a cross section of the storage building. Note the crane gallery and shielded cab from which the operator controls the crane. He must observe his work through a periscope.

Fig. 1 also shows ventilation provisions for building. The flow of air through the building is always maintained so radioactivity cannot progress from contaminated areas to clean areas. Filtered air flows controlled differential pressure into cells and pipe tunnel through cracks in cell cover blocks, through ports into the air tunnel. Exhaust fans pull air from the tunnel through exhaust ventilation sand filters and discharge it to the 200-ft.-high

stack. The sand filter can remove better than 99% of the sub-micron particles encountered in normal plant operations.

Let us return to unloading. Following flushing and cooling of the cask, the remote crane removes the cover of a storage cell, then removes the cask lid. The fuel element container is then lifted from the cask, placed in the storage cell rack, and the storage cell is closed. The cask is again closed and sent back to the transfer building for decontamination and return to the shipper.

Storage cells protect the elements from damage, keep them cool and keep them in a non-critical array. This last is assured with dummy spaces in the storage racks into which a fuel element cannot be charged.

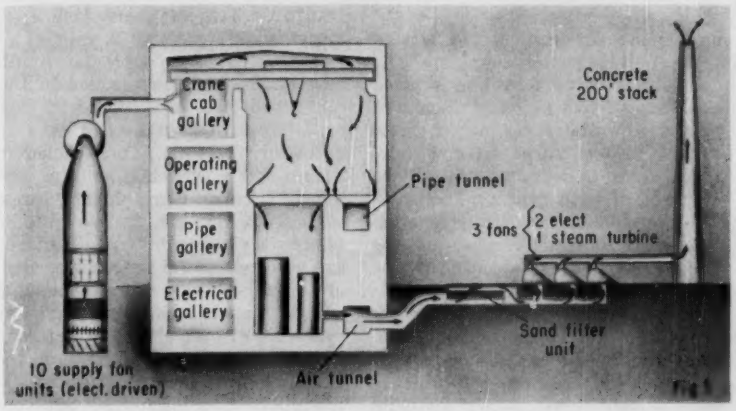
After storage comes processing. But before the nuclear material can be processed, the inert material, such as cladding and fittings, must be removed. As much as possible of this inert material can be mechanically removed before chemical processing, or the entire element, cladding, fittings and all, may be dissolved at one time. Various intermediate approaches are possible. Hanford intends to make the most of chemical processing. However, mechanical processing will be required to reduce slightly enriched fuel elements to a safe size for dissolving from a criticality viewpoint. Further, though chemical processing will be the main approach, mechanical removal of massive end fittings and subcomponents can improve processing operations by reducing chemical consumption, waste volumes or time cycles.

Mechanical Processing

Mechanical operations, which include sawing and shearing, will be performed by remote control in the mechanical cell. This cell is a particularly hazardous area because of the radioactive fines generated during the shearing and sawing operations. In addition, some of the materials handled, such as zirconium and metallic uranium, are pyrophoric, i.e. can burn on contact with air. These conditions require extreme precautions against the spread of radioactive contamination and for the protection of personnel.

Fig. 2 is a cut-away view of the mechanical cell.

Section of Processing Building Shows Shielded Crane Cab



The mechanical cell will be located in the same building as the storage cells; will be, in fact, a converted storage cell. It will be a stainless steel lined cell within a cell, the outer cell being filled with water above the floor level of the inner cell to prevent the escape of contaminated air. All objects entering and leaving the mechanical cell, including small tools, will go through the outer cell through water locks to the inner cell. All operations will, of course, be remote controlled from operating areas and will be observed through strategically located shielding windows.

Pyrophoric materials will be sawed under water. Other materials will be sawed or sheared in air.

Though most of the fines generated in the sawing and shearing operations will probably fall into the water at the bottom of the cell, enough will not so that the mechanical cell is a special ventilation problem. A circulating filter system within the cell will filter the cell air and remove any particulate material that may be present. Hanford plans a conventional wet scrubber system for this purpose.

Water containing fines from the air scrubbing system will discharge into the cell water system, which will be filtered in turn by a circulating water system. Material recovered on the circulating water filter can be charged either to the dissolver for recovery of fissile material or to a disposal canister if no fissile material is present.

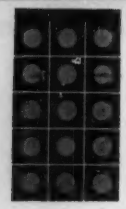
The mechanical cell will also serve as an inspection center for dissolver debris before its disposal to assure complete recovery of fissionable material. The dissolver canister will return to the mechanical cell entry lock from the dissolver after the dissolution step. If, on examination, the debris is found free of nuclear material, it will be placed in a burial canister for disposal. If nuclear material is still present, the debris will be returned to the dissolver for further processing.

However, this inspection is not primarily for discovery of large amounts of undissolved material, but for accurate determination of losses, however small, for accountability purposes.

Not all fuels will undergo mechanical processing—some fuel elements will go directly from the storage cells to the dissolvers, bypassing the mechanical cell.

Chemical Processing

Chemical processing facilities at Hanford include a dissolver for removal of cladding and conversion of the fuel cores to an aqueous nitrate solution, clarification equipment for recovering core material in the cladding removal solutions and for removal of "crud" (atomic industry vernacular for undesirable solids) from the core solutions. There is also surge storage capacity, a solution transfer pipeline, solvent extraction recovery facilities and stor-



age space for radioactive wastes from the processing complex.

Installation of new and revised equipment in an existing plant will provide the first three steps: dissolution, feed clarification and storage. Liquid and dry wastes will be disposed of with existing facilities.

A word about the transfer pipeline is in order. Because of the dangerous and valuable nature of the solutions, ordinary single-wall pipe is not suitable. Even the possibility of a leak caused by corrosion, accident or other means cannot be tolerated. Therefore, the pipe is built of corrosion resistant material and is actually two pipes, one within the other. The annular space is constantly monitored for radioactivity so that any leak, however small, from the inner pipe to the annulus will be detected immediately.

Fuels Determine Process

The type of fuel and cladding determines the specific mechanical-chemical process to be used. Five fuels are presently assigned to Hanford. Two of these have Zircaloy-2 cladding 27 to 33 mils thick and UO_2 cores up to ½ in. in diameter. Two others are clad in aluminum 35 to 40 mils thick with UO_2 or U-Mo cores up to 340 mils in diameter. The fifth fuel is clad in 21 mil stainless steel with a 300 mil UO_2 core. Enrichments range up to 3.4% U^{235}, lengths are up to 9½ ft. and fuel assembly cross sections are as large as 7.5 in. square. Several of the fuels contain internal and external hardware, such as spacers and tube sheets, which may be of different material than the cladding. For instance, one fuel is nominally aluminum clad but contains internal and external stainless steel tubing for flow control.

Chemical processing at Hanford will involve two dissolution steps chemically tailored to the fuel concerned. These steps will be cladding removal followed by core dissolution. There will be five processes for the four cladding-core fuel combinations scheduled for Hanford. These are not mild processes — dissolution generally involves highly corrosive reagents. The processes generate large quantities of gas including ammonia and hydrogen, and the cladding removal solutions tend to attack the fuel materials.

We will now discuss each process in somewhat greater detail, dealing first with the projected method of cladding removal, then fuel dissolution.

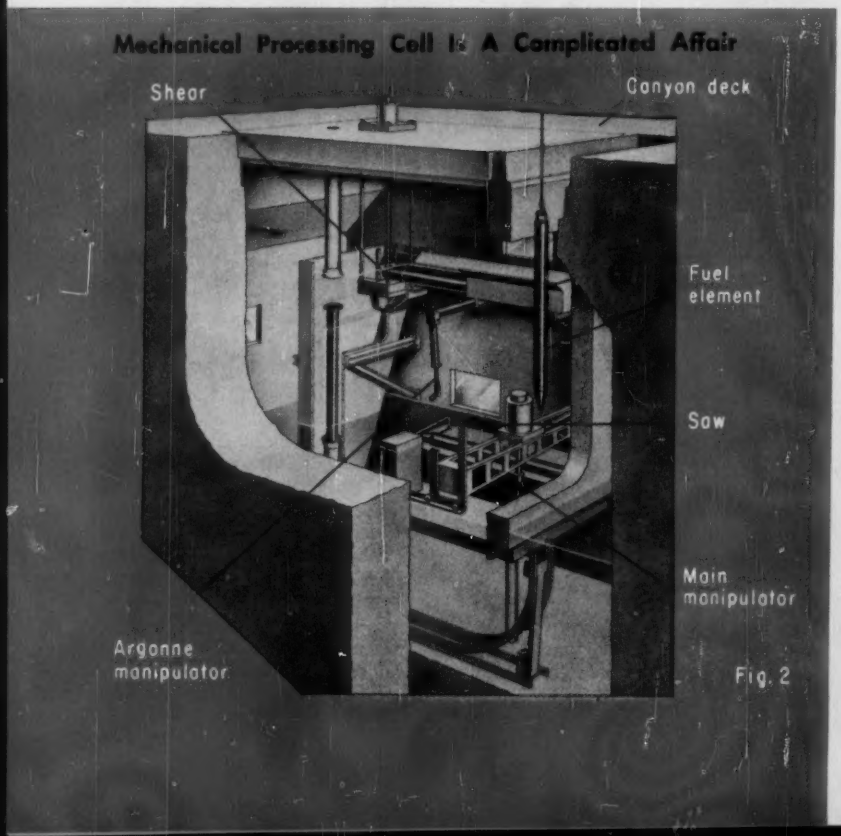
▶**Stainless Steel Removal**—Four-molar sulphuric acid dissolves Type 304-L stainless steel at a penetration rate of about 12 mils/hr. The process may require the addition of actively corroding iron to initiate the reaction. Each mol of stainless steel dissolved causes the evolution of 1.0 to 1.5 mols of hydrogen, requiring the use of an air or inert gas bleed to eliminate potential explosion problems.

Dissolution and solubility rates of UO_2 in $4M$ H_2SO_4 are both much less than those for stainless steels. Such reaction solubility effects should limit uranium losses to the range 0.1-0.5% for UO_2 fuels. However, it might be necessary to centrifuge cladding waste to recover uranium precipitates or particulate UO_2.

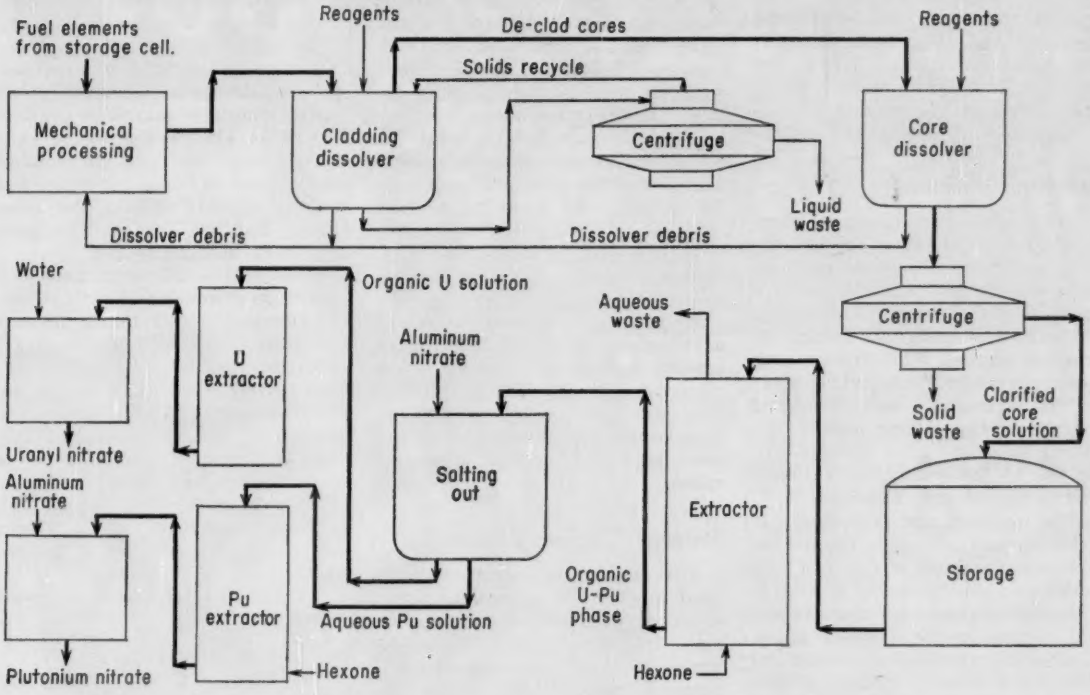
Hexavalent uranium is reactive and soluble in sulphuric acid. Proper equipment design and flushing of the equipment to remove oxidants before cladding removal operations are started will prevent formation of hexavalent uranium.

▶**Zircaloy Removal**—As mentioned, two of the fuels scheduled for Hanford are clad with Zircaloy, a zirconium alloy. Hanford will remove this cladding with the Zirflex process which uses ammonium fluoride-ammonium nitrate mixtures for selective dissolution of Zircaloy without appreciable attack of the UO_2 cores. Dissolution rates of oxidized Zircaloy should be in the range of 2-3 mils per hour, thereby requiring 10 to 15 hours to dissolve a 33 mil cladding. Though ammonium nitrate greatly reduces hydrogen production, dissolution of one mol of Zircaloy will yield about 0.1 mols of hydrogen and 6 mols of ammonia. Bleed air will keep the hydrogen below the explosive limit throughout the off-gas train and will keep the ammonia non-explosive until it is removed in the condenser scrubber system.

Zirflex solutions attack fuel materials. Fuel losses are primarily determined by the solubility of



Chemical Flowsheet Is Straightforward, Does Not Indicate Special Problems



uranium and by the efficiency of removal of uranium particles in the cladding waste solutions. Proper design and operation should reduce or eliminate the presence of oxidants or hexavalent uranium.

► **Aluminum Removal**—Sodium hydroxide-sodium nitrate mixtures will selectively dissolve aluminum claddings. Dissolution rates are in the range of 10 mils per hour, requiring about 4 hours for the removal of a 40 mil cladding. This process produces about 0.25 mols of ammonia per mol of aluminum dissolved.

Mercuric nitrate catalized nitric acid-ferric nitrate mixtures will completely dissolve both the cladding and the core of aluminum clad fuels. This single dissolution method is an alternate approach to chemical processing of these fuels.

Fuel Processing

After chemical removal of the cladding, conventional unit operations separate the cladding solution from the undissolved fuel material. Cladding solution will be clarified in a critically safe centrifuge to recover any uranium precipitates or fines that may be present.

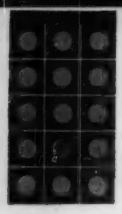
Supernatant liquids and slurries leaving the centrifuge will be sampled to determine uranium and plutonium content. Solids with recoverable values will be recycled to the dissolver.

► **UO_2 Dissolution**—Uranium dioxide fuels readily dissolve in nitric acid. Dissolution rates vary depending on the history of the UO_2 and on the concentration of nitric acid and uranyl nitrate in solution. Average rates of 10 to 70 mils per hour may be readily obtained. Off gases produced are essentially nitrogen oxides which require oxygen for acid recovery. Cores that powder or disintegrate to produce large surface areas will probably require incremental acid addition to limit dissolution rates. No particular difficulties are expected in the storage, transfer or plutonium oxidation of these solutions.

► **U-Mo Dissolutions**—Uranium-molybdenum core alloys can not be dissolved in nitric acid without precipitation problems. However, addition of ferric nitrate to the nitric acid increases dissolution rates and reduces precipitation. Dissolution rates of U-Mo alloys in such mixtures are relatively high, about 50 mils per hour, which means that the reagents should be added incrementally to avoid overloading the off-gas system. Again, the off-gases are primarily nitrogen oxides.

Core dissolver solutions will be centrifuged to remove crud. The clarified solution will then be diluted to always safe levels (0.9 *M* UNH for 5% enrichment and 1.65 *M* UNH for 3% enrichment) and adjusted in acidity for storage in non-critically safe tanks. Dissolver debris will be sent to the mechanical cell for examination before disposal.

During storage of the solutions, temperatures, liquid levels and



compositions will be monitored to detect and avoid hazardous off-standard conditions. Upon demand, the stored solutions will be transferred to the solvent extraction plant for further processing.

Solvent Extraction

The last stage of chemical processing at Hanford is solvent extraction of the dissolver solutions to recover decontaminated uranium and plutonium solutions.

Hanford is using the Redox extraction process. This process uses hexone (methyl isobutyl ketone) as the extractant and aluminum nitrate as the salting agent. Dissolver solutions from storage will be fed to the extraction columns and contacted with hexone.

The uranium and plutonium are preferentially soluble in the hexone to which aluminum nitrate has been added as a salting agent. Waste fission products and inert material are left behind in the aqueous phase. A reducing agent added to the metal containing organic phase changes the valence of the plutonium from +6 to +4, allowing it to be re-extracted to the aqueous phase. Additional contact of the now separate uranium and plutonium streams with hexone further decontaminates them.

Both the final uranium and plutonium cycles in this plant are followed by ozonization treatment which should remove residual ruthenium and produce satisfactorily decontaminated products.

The Redox process works best with a basic feedstock. Thus feedstocks prepared from U-Mo alloys will pose additional problems since these solutions are and must remain acidic to avoid precipitation problems. A decontamination loss will be experienced with this material over the first cycle but it should be partially recovered in later cycles.

Waste Disposal

A major product of a plant of this type is a large quantity of high and low level radioactive waste. These wastes are potentially highly toxic and some of them must be contained in a safe and economic manner for periods ranging up to hundreds of years. Climatic and geological conditions at Hanford permit the use of rather simple tanks for liquid disposal. These tanks are built of concrete with carbon steel liners and are equipped with the necessary monitoring devices. Highly active wastes continue to generate considerable heat for several years after disposal, enough heat so that there must be provision for cooling the tanks to prevent boiling.

Dry wastes are buried in a "garden" on the Hanford reservation.

An advantage of local storage of dry wastes over burial at sea or in caverns is that it is cheap and one always knows where the material is. Any accidental escape of radioactive material can be detected immediately and prompt measures taken.

Materials of Construction

The highly corrosive reagents used in chemical processing make a proper choice of materials difficult. Use of several different reagents required for processing different types of fuels makes the choice even more difficult. The construction material must withstand liquid, interface and vapor corrosion for the five processes outlined. It must not offer any exceptional fabrication difficulties. It must have sufficient mechanical strength to withstand mechanical shock, and it must be resistant to radiation. These requirements preclude carbon steel, clad metals and plastics. For sulphuric acid conditions only, Ni-o-nel (a chrome-nickel alloy) welded with Ni-o-nel would be best. However, for the varied conditions at Hanford, vacuum melted Hastelloy F welded with Ni-o-nel is recommended.

Criticality Problems

No discussion of nuclear fuel processing would be complete without mention of the special problem introduced when processing slightly enriched uranium. Criticality problems arise in solid metal-liquid suspension systems when the enrichment is greater than that of natural uranium (0.7114%) and in liquid systems when the enrichment is greater than 0.94% U^{235}. There are several ways to assure safety in handling these materials: geometric limitations where equipment is so designed that fissile material cannot develop a critical geometry; batch operation where the quantity of material handled is always less than critical size; concentration control where the maximum concentration is always limited to safe levels; and the use of soluble poisons such as boron to provide for neutron capture within the solutions. Hanford prefers the geometrically safe technique.

Since at 5% U^{235} enrichment the maximum cylinder size permissible is 7.8 in. in diameter, maximum slab thickness is 2.9 in. and the maximum permissible area of a rectangle or square is 47.8 in., rather small equipment is indicated for the portion of the dissolver handling solid metal-liquid mixtures. As a matter of interest, the estimated always safe batch size of 5% U^{235} is 80 lbs. of material and the always safe concentration is 250 grams per liter.

Now, go forth and build your own processing plant.

ACKNOWLEDGEMENTS

This article is based upon the following papers delivered by members of the Hanford staff at the AEC's symposium on Chemical Processing of Irradiated Fuels from Power, Test and Research Reactors held at Richland, Wash., Oct. 20-21, 1959.

In writing this article, the editors of *CE* have drawn more from some papers, less from others. Space limitations and what we feel to be the interests of our readers dictated the material included here. Necessarily, much valuable and interesting information, particularly on measurements, could not be included.

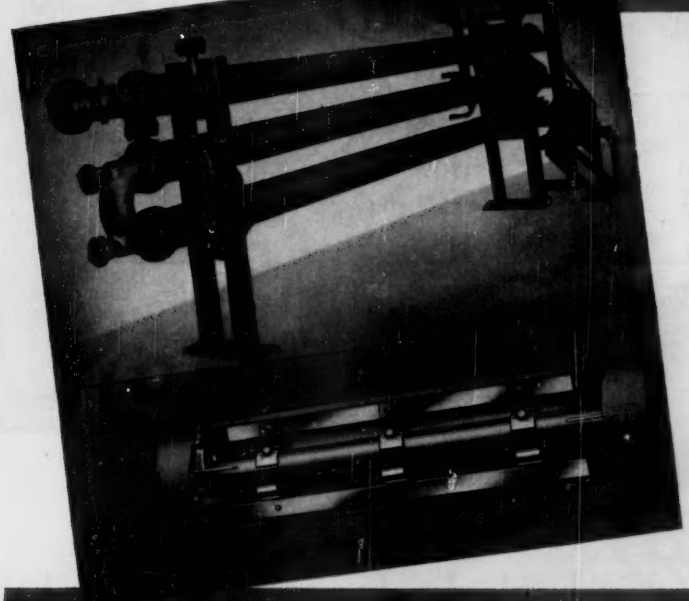
The papers are: "Chemical Processing of Irradiated Fuels from Power, Test and Research Reactors" by V. R. Cooper, "Receiving, Storage and Mechanical Processing Operations at Hanford" by Lyle Zahn, "Chemical Processing of Power, Research and Test Reactor Fuels by the Hanford Atomic Products Operation" by A. M. Platt, and "Measurements" by K. M. Harmon and R. A. Schneider.

The complete proceedings of the symposium are available from the Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Bulletin TID 7583.

Vogt

SCRAPED SURFACE EXCHANGERS *Solve* these Special Heat Transfer and Crystallization Problems . . .

BELOW: *A scraped surface unit for production of Para-Xylene by fractional crystallization. Insert shows detail of Vogt Spring Type Scraper.*



. . . *And Here's How:*

1. Rotating scraper action continuously sweeps surfaces clean even while processing highly adhesive materials.
2. Uniform rate of heat transfer keeps crystallization under control and discharges crystals as a slurry.
3. Product is thoroughly mixed by scraper blades as it flows.
4. Closed, pressure-type system permits use of flammable, volatile and expensive solvents with complete safety and no solvent loss.
5. Units fabricated from a broad range of materials to suit process stream characteristics.

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- Caustic Soda
- Caustic Potash
- Clay
- Cylinder Stock
- Para-Dichlorbenzene
- Fatty Acid Solutions
- Fish Oil
- Linseed Oil
- Naphthalene
- Paratone & Solids
- Phenolic Resins
- Polyester Liquid
- Pressed Distillate
- Reduced Petroleum
- Waxy Oil-Solvent Mix
- Soybean Oil
- Sperm Oil
- Sugar Syrup
- Sulfur-Oil Mix
- Sulphate Solution
- Tall Oil-Naphtha-Sulfuric Acid Solutions
- Tetrachloro Benzene
- Viscose
- Wax Slurry
- Para-Xylene

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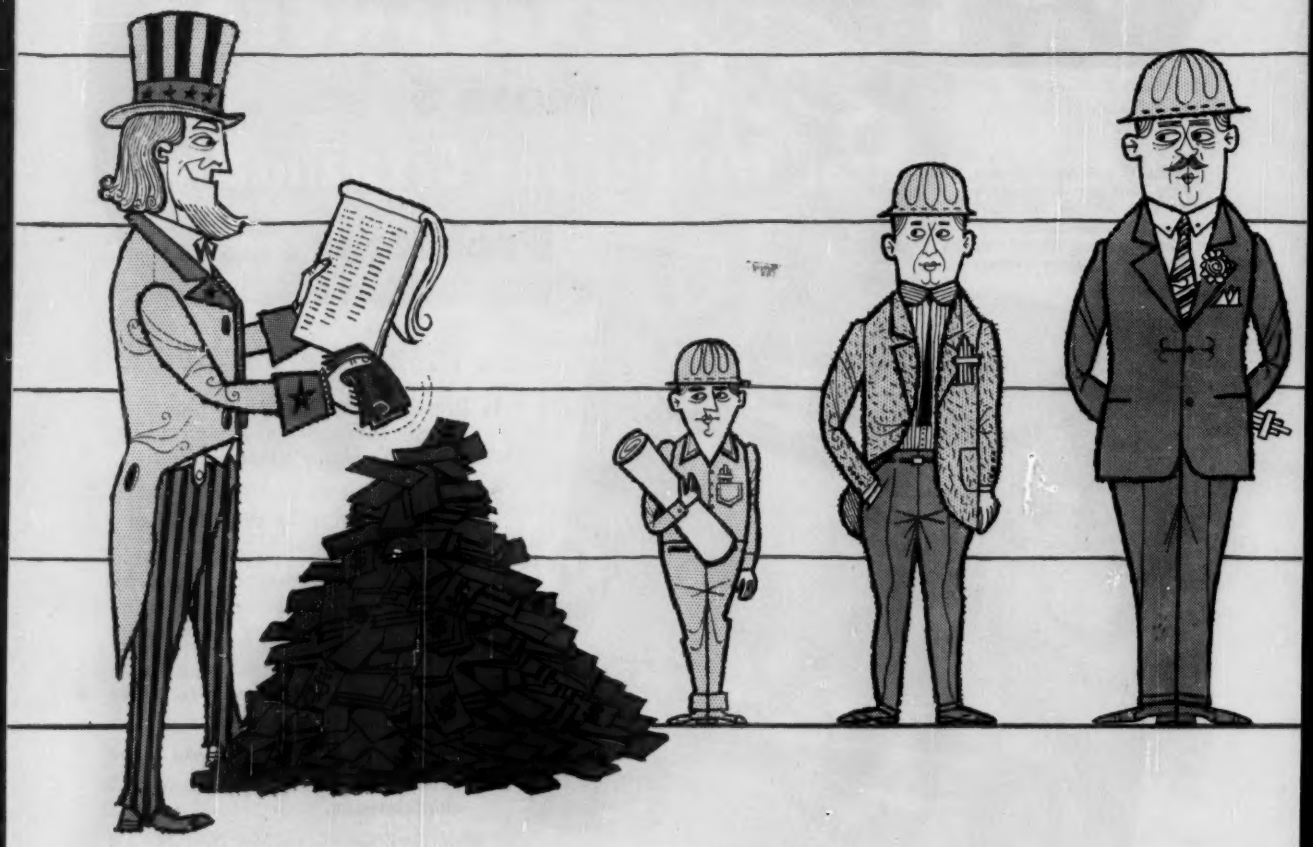


A New Yardstick for Measuring

Have you been skeptical about the accuracy of existing surveys? Would you be willing to rely on this national estimate of engineers' salaries?

Someday soon, if your employer is included in the survey sample, an interviewer from the U. S. Dept. of Labor's Bureau of Labor Statistics (BLS) will be inquiring about your salary.

BLS has begun this month an ambitious project. Between now and the end of the fiscal year in June they will conduct personal field interviews with the wage and salary administrators of 1,400 establishments.

These firms have been carefully selected as being representative of employers in 60 metropolitan areas of the U. S. (And the 60 areas will constitute a representative sample of the 188 metropolitan areas of the U. S.)

Based on the survey results, BLS plans to announce in December a national estimate of industrial rates of pay for the white-collar jobs listed in the accompanying table. Engineers will be covered in six job grades. Chemists and directors of research will also be included, as well as attorneys, auditors, office and personnel managers.

► **Comparable Rates of Pay**— When the nationwide estimates

Survey Includes Engineers And Other White-Collars

Clerical Supervisory

Managers, office service
Supervisors, key punch
Supervisors, payroll
Supervisors, tabulating

Accountants and Auditors

Personnel Management

Job analysts
Employment managers
Directors of personnel

Attorneys

Engineers and Scientists

Chemists, Grades I, II, III, IV, V, VI

Engineers, Grades I, II, III, IV, V, VI

Mathematicians, Grade I, II, III, IV, V, VI, VII
Directors, res. and dev.

Your Pay

of industrial salaries for these jobs are available, the Bureau of the Budget (Executive Office of the President), the Civil Service Commission, the Special Assistant to the President for Personnel Management and the Congress will have available data for appraisal of the federal pay structure in relation to going rates in industry.

The President has stated on several occasions that federal pay should be reasonably comparable with nonfederal pay for similar work.

An inter-agency group, composed of representatives of federal agencies concerned with salary administration, designed the survey. This group reviewed existing surveys and concluded, "Neither individually or collectively do these surveys . . . provide representative data for a reasonable sample of federal jobs."

This announcement took *CE* by surprise, since we were highly laudatory concerning the results and validity of the most recent Engineering Manpower Commission-Engineers Joint Council survey of engineers' salaries (*Chem. Eng.*, Mar. 23, 1959, p. 188). This survey covered about one fifth of all engineers employed in industry, and that seemed to be a reasonably dependable and statistically significant sample of the entire engineering population.

Checking with Roy Wheelock, who directs the EMC-EJC survey, *CE* learns that in 1960—as the result of additional employers having asked to be allowed to participate — Engineers Joint Council will be tabulating and plotting the salaries of as many as 250,000 engineers. And this will be going on at the same time that the BLS interviewers will be out in the field.

Why this apparent duplication of effort?

▶ **Off to Washington**—To get the answer to this question, *Chemical Engineering* went to Washington and interviewed T. P. Kanninen, Division of Wages and Industrial Relations of BLS, who will supervise the survey operation and prepare the national pay estimates to be used by the Bureau of the Budget.

According to Kanninen, the forthcoming white-collar survey reflects the need of the federal government for a consistent body of salary data for a wide range of occupations, including engineering occupations. It is primarily for this reason that survey information from diverse sources cannot be combined to provide the kind of salary profile needed for federal administrative purposes.

With specific reference to the EMC-EJC survey, Kanninen said that it undoubtedly has great value for engineers. However, for federal use, the survey has a major limitation. In the EMC-EJC survey—and in the Los Alamos salary surveys—salary data are plotted against years since the B. S. degree. Data are not collected in terms of engineering work levels.

For federal use, national estimates of salaries paid for each of six carefully defined work levels, corresponding with levels found in federal service, are required.

Kanninen also pointed out that many professional surveys are confined to society membership lists. Since all persons in the profession are not society members, salary data derived in this way may not be acceptable.

▶ **Already Pretested** — The new BLS survey has already passed a successful pretest. BLS for some years past has been surveying blue-collar wages and clerical pay in about 20 metropolitan areas and has been issuing reports on these committees.

These community surveys are now expanded to cover 80 metropolitan areas. The plan is to extend the occupational scope of the existing surveys in these areas to include professional and managerial pay. This year BLS will interview 1,400 employers in 60 metropolitan areas. Between July 1960 and June 1961, 2,100 employers in 80 areas will be interviewed.

To see how this would work in actual practice, BLS has already gone through a pretest of 35 establishments (total employment = 120,000) in 11 widely distributed labor markets. Kanninen, who conducted some of the pretest interviews, is convinced that the plan can work on a national basis.

However, mail or telephone surveying will not do the job. Each of the 1,400 employers to be surveyed this year will be interviewed on a face-to-face basis by a trained BLS interviewer. Assuming that each interview takes the better part of a working day (many will require more than one working day) you can see that BLS has quite a job ahead of it.

To meet the challenge, BLS is summoning its most experienced people to Washington to be trained for this special work. Top-level BLS personnel will be separated from other duties for this assignment. Some of them have accumulated as much as

20-25 years of experience in wage-survey work.

▶ **Jobs Must Match**—Most troublesome factor in the survey will be the proper matching of job specifications. BLS interviewers will be required to extract enough information about each industry - employed white - collar worker so that a correct decision can be reached about matching him to one of the standard job descriptions.

The white collar jobs on which pay data will be sought are a representative sample of Classification Act occupations GS-1 through GS-15. Industry pay for work equivalent to GS-16, 17 and 18 will be the subject of supplemental case studies by the Civil Service Commission.

Engineers, for example, will be matched to the following six abridged job descriptions.

▶ **An Engineer Is** — According to BLS, an engineer performs research, development, design, testing, analysis, production, construction, maintenance, operation, planning, survey, estimating, application, or standardization of engineering facilities, systems, structures, processes, equipment devices, or materials requiring knowledge of the science and art by which materials, natural resources and power are made useful.

Work typically requires a B. S. degree in engineering or its equivalent in experience and education combined. Safety engineers, industrial engineers, quality control engineers and sales engineers are to be excluded.

Engineer Grade I—Performs professional engineering work of a beginning level under close supervision with assignments planned to provide experience and familiarization with methods and practices of the company in the specialty field.

Performs routine tasks such as taking measurements, compiling data, setting up equipment, preparing drawings, performing calculations, etc., according to specific and detailed instructions. Typically receives formal classroom instruction or on-the-job training.

Engineer Grade II—Performs routine engineering work requiring the independent application of standard techniques, procedures and criteria in carrying out a sequence of related engineering operations with limited requirements for the exercise of judgment on details.

Usually performs limited portions of a broader assignment of an experienced engineer. Supervisor screens assignments to eliminate difficult problems and selects techniques or procedures to be applied. May receive advanced on-the-job training or classroom instruction.

Engineer Grade III — Performs engineering work requiring the independent evaluation, selection and application of standard techniques, procedures and criteria with ingenuity in making minor adaptations and modifications.

Assignments include equipment design and development, test of materials, preparation of specifications, process study, research investigation, report preparation, etc.

Unusual problems are solved jointly with supervisor and work is reviewed for application of sound engineering judgment.

Engineer Grade IV—Performs engineering work requiring originality and judgment in the independent evaluation, selection and substantial adaptation or modification of standard techniques, procedures and criteria.

Some characteristics of many positions of this type are:

Plans, schedules and coordinates phases of the engineering work in a part of a major project, or in a total project of moderate scope. Devises new approaches to problems encountered in projects.

Supervises small group of engineers and technicians.

Receives direct supervision and guidance primarily on novel or controversial problems. Makes unreviewed technical decisions on details of work covered by precedents.

Engineer Grade V—Plans, develops, coordinates and conducts a large and important engineering project or a number of small projects with many complex features.

Positions may be either supervisory or nonsupervisory. The following are characteristic of both types of positions:

Makes decisions independently on engineering problems and methods. Represents the organization in conferences to resolve important questions, and to plan and coordinate work.

Receives supervision and guidance only in terms of specific objectives and on critical issues involved.

Engineer Grade VI — Programs, plans, coordinates a number of large and important projects of major scope and importance. Positions may be either supervisory or nonsupervisory:

- Supervisors direct and control a staff of project engineers and assistants, and a number of technicians and draftsmen. They also evaluate progress of the staff and the results obtained and recommend major changes to achieve over-all objectives.
- Nonsupervisory positions include advisory, consulting and other review work as specialists or experts in a specific field or related areas.

The following are characteristics of both types of positions:

Maintains liaison with other companies and organizations.

Conceives, plans and executes engineering projects involving exploration of subject area, definition and selection of problems for investigation and development of novel design concepts and approaches.

Usually has final technical responsibility for interpreting, organizing, executing and coordinating assignments.

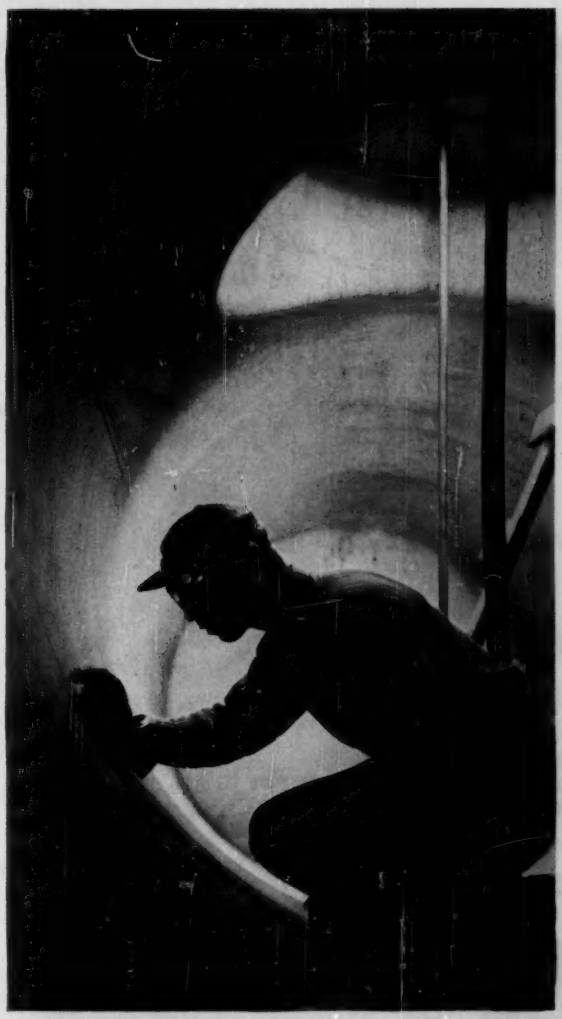
▶ **Only the Beginning**—In addition to asking about pay rates, BLS intends to gather data on a few supplementary questions. For example, is there any pay distinction between the starting salaries offered to new entrants to the field, or do most employers set a fixed starting rate and stick to it?

As BLS acquires more experience in the field, surveying white-collar salaries, you can be sure that changes in the design of the survey will evolve.

In this year of census taking, someone will be ringing your doorbell to ask some personal questions. And you'd better alert your salary administrator, also. The BLS intends to ring his buzzer from now on.

HYPALON® TANK LININGS KEEP CAUSTIC SODA IRON-FREE AT 285° F.

A major producer of caustic soda has operated nine experimental tank cars since February, 1957. These cars were sprayed with an 8-10 mil thickness of HYPALON. Results after nearly three years: HYPALON lining has retained its light color and smooth finish. The spray coating in the tank car at right was recently inspected. It has withstood 50% and 73% caustic soda shipped at temperatures as high as 285°F. and still needs no maintenance.



Tank linings made from HYPALON can handle highly oxidizing acids at temperatures that would quickly destroy other types of rubber linings. Because of their unique resistance to oxidation, HYPALON linings have gained recognition in handling chemicals like calcium and sodium hypochlorites, chromic acid (50%), phosphoric acid (85%), sulfuric acid (80%), nitric acid (30%) and various pickling acid solutions.

HYPALON is resistant to corrosive chemicals, abrasion, ozone, sunlight, weather, high temperature (up to 350°F.)—all this plus its flame resistance and permanent colorability—make it an extremely versatile elastomer. Rubber maintenance products which offer the long-term economy of Du Pont HYPALON and neoprene are available from your local rubber goods distributor. He can suggest the right product for any job you need performed. Take advantage of his experience and services soon.

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CE COST FILE

No. 22: Process Control Instrumentation

F. C. Vilbrandt, Virginia Polytechnic Institute & C. E. Dryden, The Ohio State University

Cost of Process Control Instrumentation

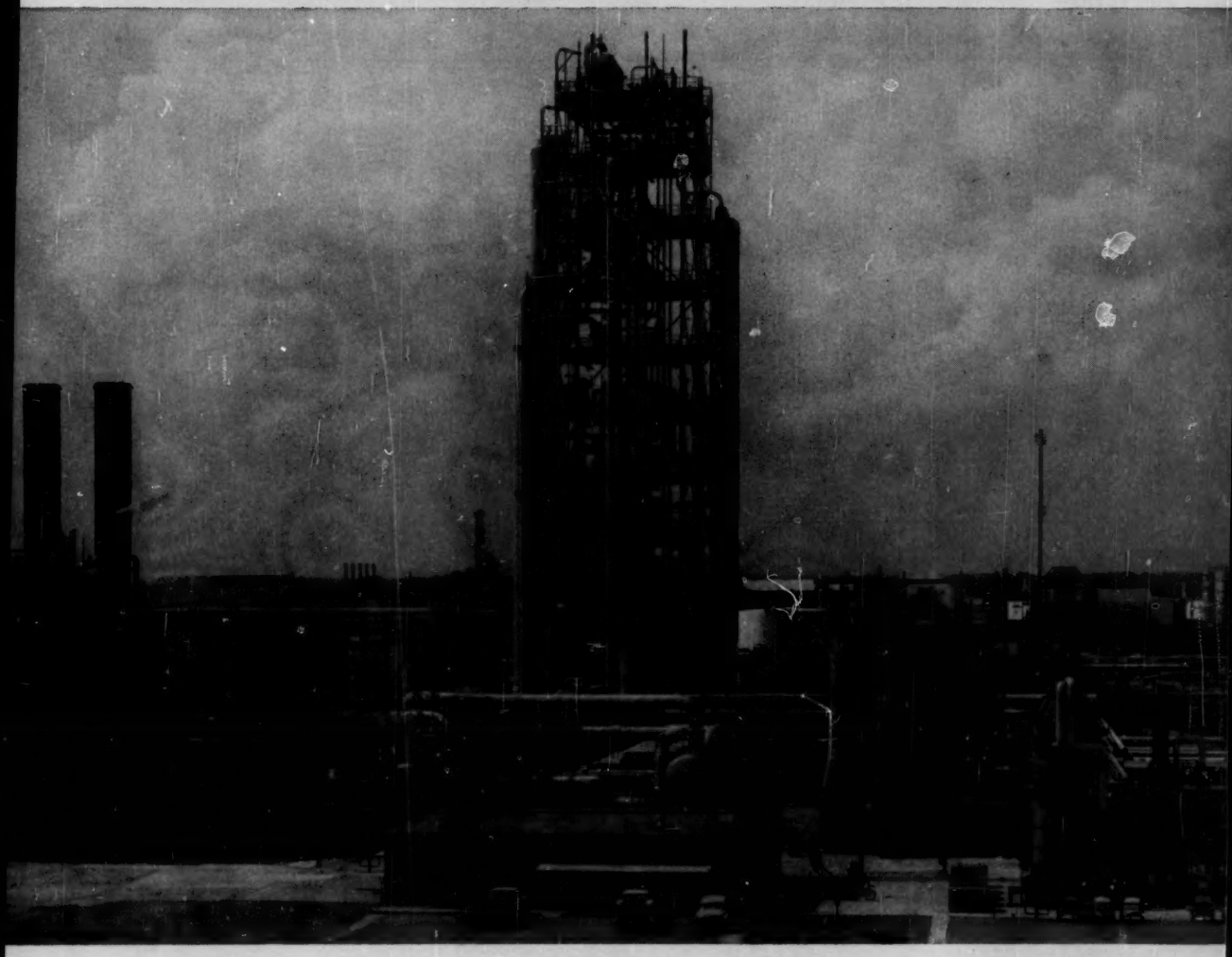
Information in this Cost File is based on material that appears in the new fourth edition of "Chemical Engineering Plant Design," McGraw-Hill, New York, 1959. This edition has expanded coverage of costs, including replots of most cost information that has appeared in this magazine in the past on the basis of EN-R Construction Index of 750 (mid-1958).

The following table, F.O.B. factory quotes of major instrument manufacturers, shows typical price ranges for control instruments, July 1958. Add 35% of average base price for installation charges on instruments costing less than $2,000. Add 20% for those over $2,000.

Element	Price Range, Dollars Low	Average	High
Temperature			
Differential expansion thermostat	10	25	40
Indicating expansion thermometer	60	145	230
Indicating resistance thermometer	100	310	600
Indicating pyrometer	100	225	300
Pressure			
Indicating bourdon-type gage (noncorrosive conditions)			
0–500 psi	20	75	160
0–10,000 psi	35	115	200
0–30 in. vacuum	25	105	160
Indicating bourdon-type gage (corrosive conditions requiring diaphragm seal)			
0–500 psi	85	140	225
0–5,000 psi	110	170	250
0–30 in. vacuum	75	150	225
Strain-gage load cells	240	360	975
Indicating vacuum gage—McLeod type	300	400	500
Fluid flow			
Volumetric meter			
Nutating disk meter	200	350	500
Rotary vane meter	200	350	500
Liquid-sealed gas meter	100	200	300
Variable head			
Indicating orifice meter	180	400	595
Indicating venturi meter	110	360	700
Variable area meters			
Indicating tapered tube rotameter	30	320	950
Velocity meters			
Electric current turbine wheel meter	450	730	1,000
Electromagnetic flowmeter	775	3,290	7,800
Hot wire anemometer	300	440	620
Level			
Float type			
Gage glass	75	150	200
Tank float with external indicator	200	810	1,590
Hydrostatic			
Differential gage	40	210	400
Continuous capacitance	300	400	500
Level (contd.)			
Radioactive ray absorption	465	1,230	2,000
Strain gage weighing			
50 lb.–5 tons	540	600	625
10–50 tons	825	1,200	1,550
Density			
Photoelectric hydrometer	120	550	1,000
Gas density balance	480	1,150	2,000
Radioactive ray absorption	2,000	3,000	4,000
Viscosity			
Continuous viscosimeter	220	2,450	4,000
Continuous consistency meter	1,500	2,300	4,160
pH	550	1,170	1,500
Electrical conductivity	200	500	800
Thermal conductivity	200	900	1,400
Combustible gas analyzers	600	800	2,000
Gas humidity	650	1,150	1,800
Spectroscopy			
Infrared	2,000	3,000	20,000
Ultraviolet	2,000	2,500	4,000
Mass spectrometry	2,500	8,000	20,000
Radio frequency	3,000	5,000	15,000
Gas chromatography	4,500	6,500	15,000
Radioactivity measurements			
Ionization	200	450	3,000
Scaler for proportional or G-M counting	500	1,100	1,500
Scintillation counters	900	1,400	4,000
Recording instrumentation			
1 point	200	500	1,200
4 points	350	800	1,400
16 points	1,000	1,500	1,900
Recording-controlling instrumentation doesn't include main control valves.			
1 point	300	700	1,600
4 points	1,400	1,500	1,750
16 points	1,800	2,000	2,250

Through an inadvertent error, we didn't credit the following source for information in Cost File 20, Dec. 14, '59; Williams, R. F., and Cogshall, J. H., *Corrosion*, Jan. 1957, p. 19.

World's Largest Ethylene Unit



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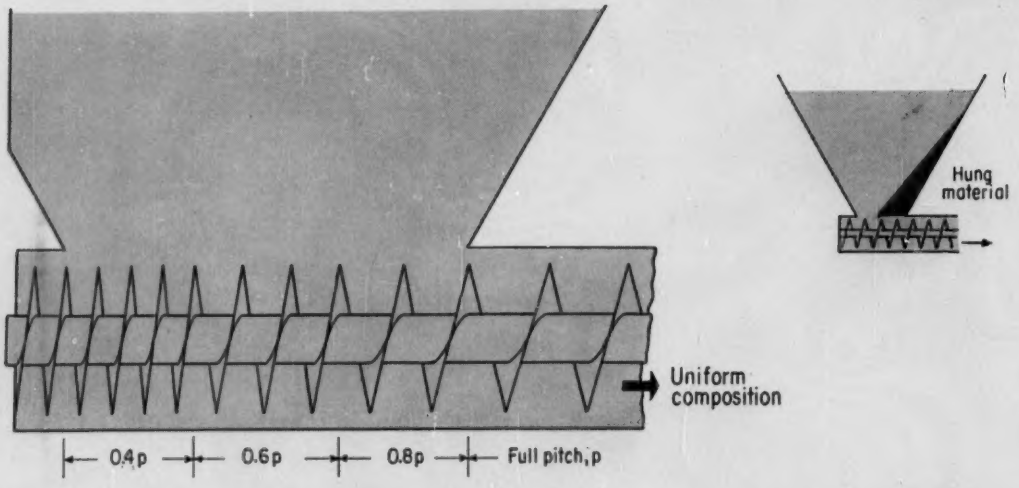


Multiple-Pitch Screw Equalizes Discharge

Tendency of some powdered materials to segregate and unload non-uniformly is overcome by redesigning the screw conveyor.

★ Winner of the November Contest by
M. S. Bass
Heyden Newport Chemical Corp., Garfield, N. J.

Conventional screw conveyors tend to unload powdered or granular material from hoppers non-uniformly. The constant pitch screw will fill up with material at the bearing end, then the filled screw tunnels under the material at the opposite side of the hopper without removing it. If the hopper is constantly refilled without ever being completely emptied, the material on the downstream side will never move, or will be only partially removed at unpredictable intervals.

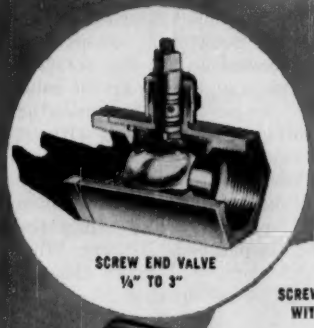
Materials with undesirable aging characteristics such as color pick-up, lump formation, moisture absorption, etc., must be unloaded uniformly or there will be quality variations from batch to batch.

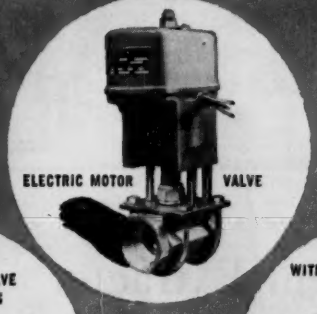
One could solve the problem by making the opening at the bottom of the hopper only large enough to keep the screw filled. But bridging characteristics of some powdered and granular materials might make this solution unfeasible.

We solved our problem with a variable-pitch, constant-diameter screw. The pitch of the screw, and thus the capacity of the screw, varies along the length under the hopper opening. At the bearing end, the screw has only one third the capacity of the full pitch screw. The pitch increases from the bearing end outwards so that as the screw revolves, it removes material uniformly from all parts of the hopper opening.

This modification, pictured above, made the entire hopper actively unloading and eliminated all the dead volume usually associated with screw conveying from storage hoppers and bins.

jamesbury "Double-Seal" BALL VALVES


SCREW END VALVE
¼" TO 3"



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FLANGED VALVE
WITH OPERATORS

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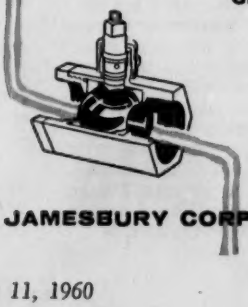

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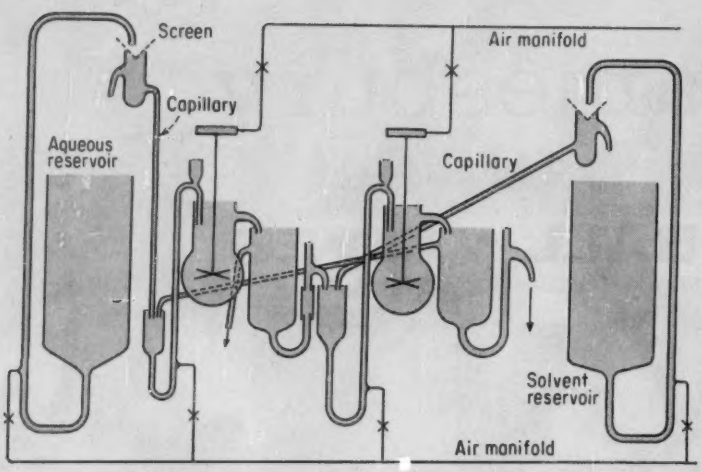


Laboratory Solvent Extractor

A. A. Mayling

Chief Chemist, Consolidated Denison Mines, Ltd., Spragge, Ontario, Canada

Occasionally the chemical engineer will find himself in the lab working out in glassware a problem encountered in the plant. Here is a laboratory setup for countercurrent solvent extraction which we find useful.

The equipment shown in the sketch is built from glass with Tygon connecting tubing. Only two sections are shown but the apparatus can be enlarged to as many sections as desired. We generally used between 14 and 16 mixer-settler sections.

The mixers are approximately 50 ml. in volume. Two sizes of settlers, 50 ml. and 125 ml., were used depending on the characteristics of the various extractor solutions.

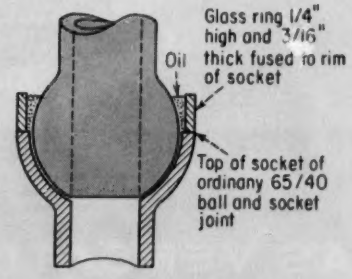
Capillary tubing controls the flows. We made these capillary controls of as long a piece of tubing as possible with a feed head of from 1 to 6 in. The capillaries are comparatively large bore so that small pieces of dirt will not block them.

Both streams are moved by an air lift. Air for the air lifts is scrubbed with the appropriate solvent to reduce evaporation losses.

Any flow in the system can be adjusted to between 50 and 1,000 ml./hr. in a few minutes. Any section—extraction, scrub, re-extraction, etc.—can be altered from one mixer-settler to as many as required in as little time.

The equipment required no operating manpower except for that needed to fill the solution reserviors and make up the solutions; we have left the apparatus running for long periods without attention.

If desired, you can modify the equipment so that one stream will flow by gravity while the other is pumped. However, this modification will make the apparatus less versatile.



Leak-Proof Joint for High Vacuum Work

V. N. Schrodt

Project Supervisor
Applied Science Laboratories, Inc.
State College, Pa.

Ground glass joints are commonly used for make or break connections in laboratory high vacuum systems. Here is a modified joint with an oil seal that eliminates the problem of air leakage through the joint at low pressures.

This joint is constructed from commercially available ground joints by fusing a glass ring to the socket half of the joints as shown in the sketch. The sealant is Dow-Corning 550 silicone oil.

We have had no signs of leakage with these joints over long periods at pressures of 0.1 mm. Hg and temperatures to 250 C.

NEXT ISSUE: Watch for December Contest Winner

★ How Readers Can Win

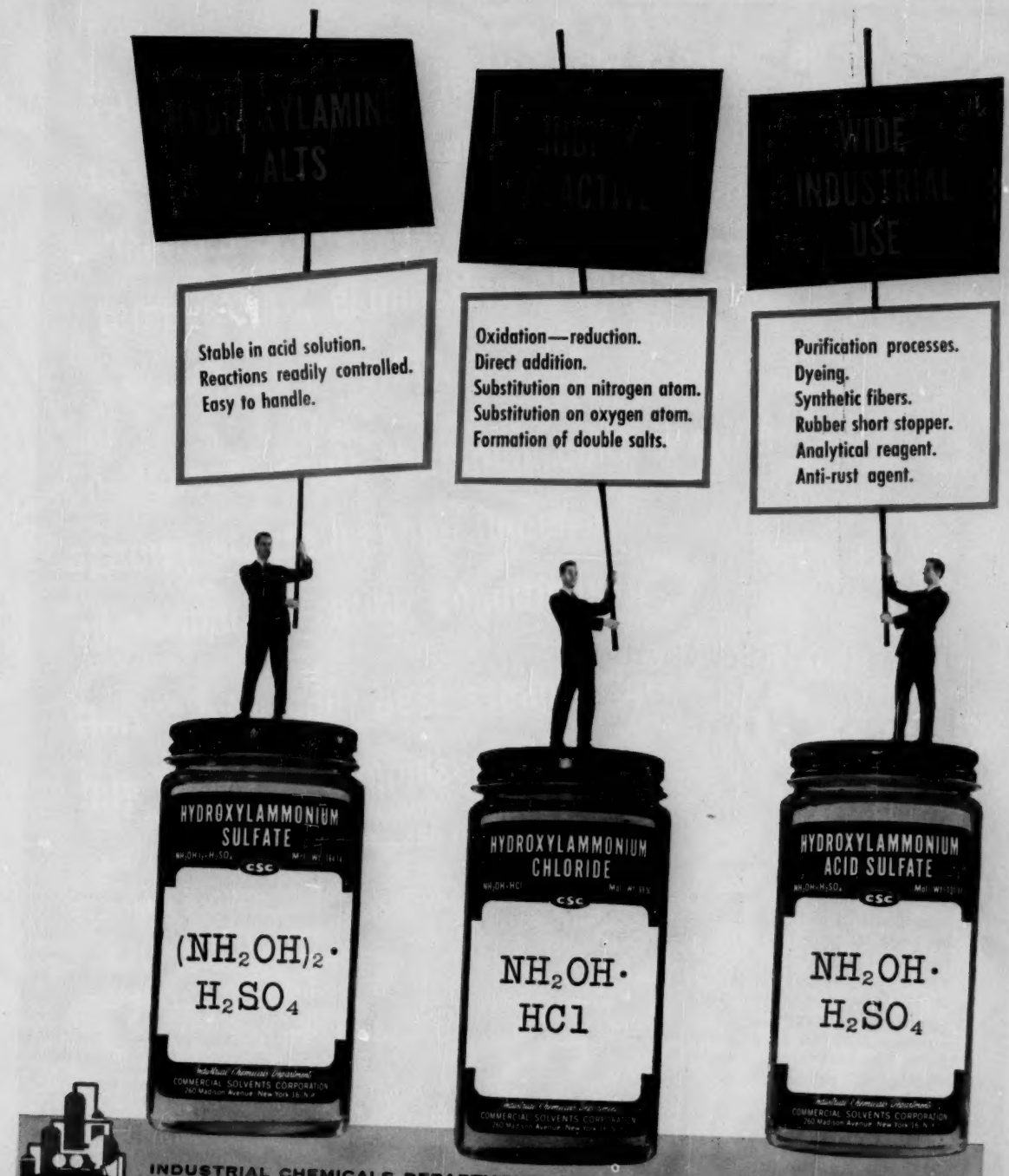
$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for Plant or Process Design Notebook.

Each period's winner will be announced in the second following issue and published in the third or fourth following issue.

$100 Annual Prize—At the end of each year the period winners will be rejudged and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable nonwinning articles will be published at space rates ($10 minimum).

Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant & Process Design Notebooks, *Chemical Engineering*, 330 W. 42 St., New York 36, N. Y.



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COMMERCIAL SOLVENTS CORPORATION

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- ☐ Sample of Hydroxylammonium Chloride
- ☐ Sample of Hydroxylammonium Sulfate
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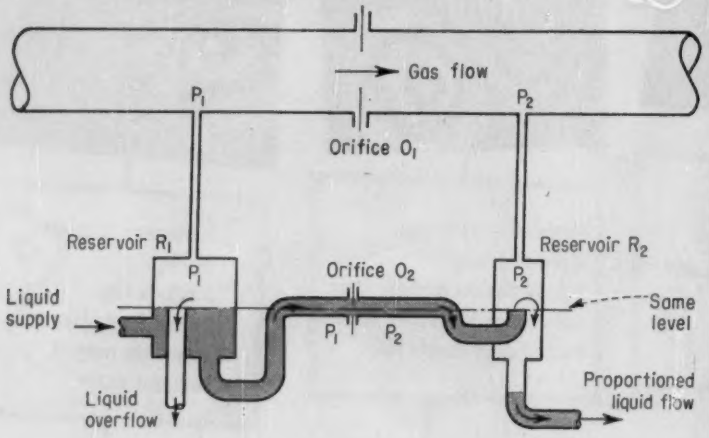
★$100 Annual Prize Winner for 1959*



Twin Orifices Proportion Liquid to Gas Flow

L. D. Brice

Process Eng., General Electric Co., Medium Transformer Dept., Rome, Ga.

Pictured above is a simple arrangement of orifices which can be used to proportion a liquid flow to a gas flow. It is simple, has no moving parts and works on the principle of two orifices connected in parallel.

I have used this device successfully for controlling a vacuum distillation process where the flow rate of the refluxed liquid was to be kept in a fixed proportion to the variable flow of a gas in the still.

The same arrangement could be used in various other situations, for example, in proportioning fuel-air mixtures or in controlling the reactants entering a process.

In the sketch, the liquid to be proportioned is fed into a reservoir R_1 in excess, so that there is always a constant level maintained by the overflow tube. R_1 is connected to and operates at the upstream pressure P_1 of gas, above orifice O_2.

A second or discharge reservoir R_2 is connected to and operates at the downstream pressure P_2 of the gas, below the orifice O_1.

A line containing a second orifice O_2 connects the supply and delivery reservoir, R_1 and R_2. Note that the liquid level in R_1, in the orifice O_2, and at the discharge point into R_2, must all be at the same elevation to eliminate any differences in hydrostatic head. Both orifices will then operate under the same differential pressure conditions and will therefore pass proportional quantities.

If one desires occasionally to vary the proportion of liquid to gas flow, a valve instead of the fixed orifice O_2 will serve the purpose.

* This article, originally published in the Sept. 21 issue, was selected by the editors as the best monthly Notebook winner for 1959. The author will therefore receive an additional prize of $100.

Slide-Rule Solution for Cubic Equations

Jesse Roth

Kearfott Co., Clifton, N. J.

Many of us have to solve cubic equations often enough to find a simple procedure convenient.

A method of rewriting a cubic equation to permit at least one root to be found on the slide rule is useful.

The general cubic $x^3 + ax^2 + bx + c = 0$ is always reduced to the form $y^3 + my + n = 0$ by the substitution $x = y - a/3$. This can be recast to the form $y^3 + n/y = -m$. There will always be at least one real value of y that will satisfy this relationship. Generally the sign and at least the order of magnitude of y can be determined by inspection. To determine the exact value of y, set the C scale index opposite the value n on the D scale. Next, move the hair line until the numbers under it on the A scale and the CI scale add algebraically to $-m$. Then the number under the hairline on the D scale is y. X is then $y - a/3$.

To try an example, consider the equation $x^3 - 8x^2 + 19x - 12 = 0$. The substitution $x = y + 8/3$ gives $y^3 - 2\frac{1}{3}y + 20/27 = 0$ or $y^3 + 0.741/y = 2.33$. We can see that a positive value of y somewhat less than $(2.33)^{\frac{1}{2}}$ would satisfy the equation. To find this value, set the C index opposite 0.741 on the D scale. Then move the slide to the point where 1.78 on A plus 0.553 on CI add up to 2.33. Under the hairline on the D scale we read 1.333 as the value of y and thus the solution of the original equation is $x = 1.333 + 2.667 = 4$.

With one root known, the original equation can be reduced to a quadratic. However, in this example we see that the equation for y would also be satisfied if y is a small positive number. A similar slide-rule manipulation gives $y=0.333$ and thus $x = 3$. Also we note that a negative value of y somewhat larger than $(2.33)^{\frac{1}{2}}$ would satisfy the equation. To determine it we again set the C index at 0.741, but move the hairline so that the A scale reading minus the CI reading equals 2.33. This gives -1.667 for y and hence $x = 1$.

YARWAY IMPULSE* is the only steam trap that continually samples fluid in the line to maintain condensate discharge close to steam temperature, eliminating condensate as soon as it forms.

Condensate seals the small control orifice against steam leakage under all normal operating conditions.

Here's why your best steam trap buy is Yarway Impulse—

1. GETS EQUIPMENT HOT FAST—AND KEEPS IT HOT
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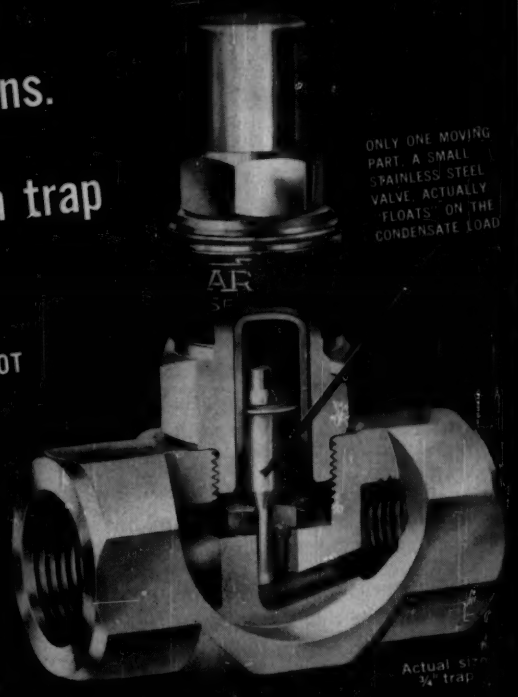

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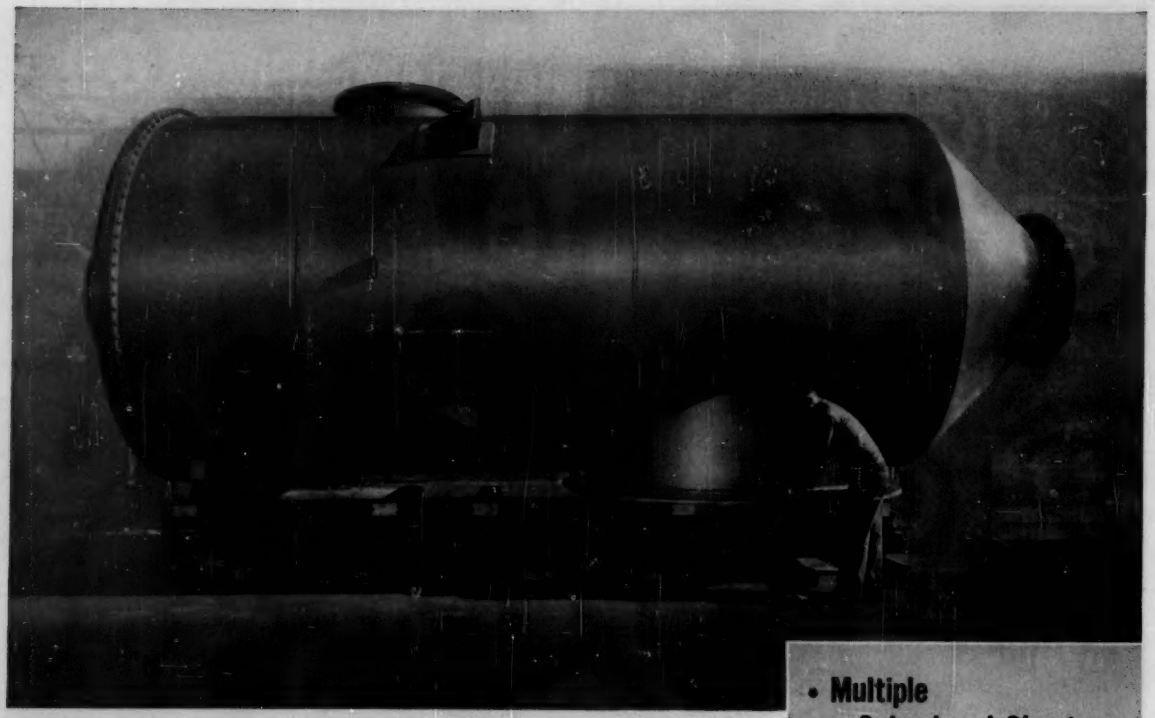
Stocked and sold by 270 Industrial Distributors
Write for free bulletin "The Why and How of Steam Trapping"



MANHATTAN RUBBER LINED TANKS for PERMANENT Protection against Corrosion and Contamination

Costly process equipment for storing and handling corrosives deserves the degree of protection possible only with specially compounded, acid-proof Manhattan Rubber Linings. Thick, multiple calendered sheets of natural or synthetic rubber assure maximum durability under rough working conditions. The linings expand and contract with the tank metal under temperature changes . . . won't harden or crack. Their protection against most acids and alkalis is as fool-proof as 65 years of advanced technology can provide.

All Manhattan Rubber Linings are bonded to metal so securely actual tests have proved they can't be separated! And every Manhattan lined tank is tested under high voltage to assure flawless protection before being shipped to your plant. If your equipment is too large to ship to Manhattan, skilled crews will do the job at your location.

Be *sure* of permanent protection for your process solutions and equipment. Let an R/M representative show you the advantages of Manhattan Rubber Lined tanks, pipe and process equipment. Contact the Manhattan Rubber Lining plant or sales office nearest you . . . or write direct.

- **Multiple Calendered Sheets**
- **Permanent Protection Against Corrosion, Contamination**
- **Permanent Rubber-to-Metal Bond**
- **Resistant to Acids, Alkalis, Abrasion, Temperature**
- **Largest Facilities Longest Experience**
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ENGINEERED RUBBER PRODUCTS . . . MORE USE PER DOLLAR

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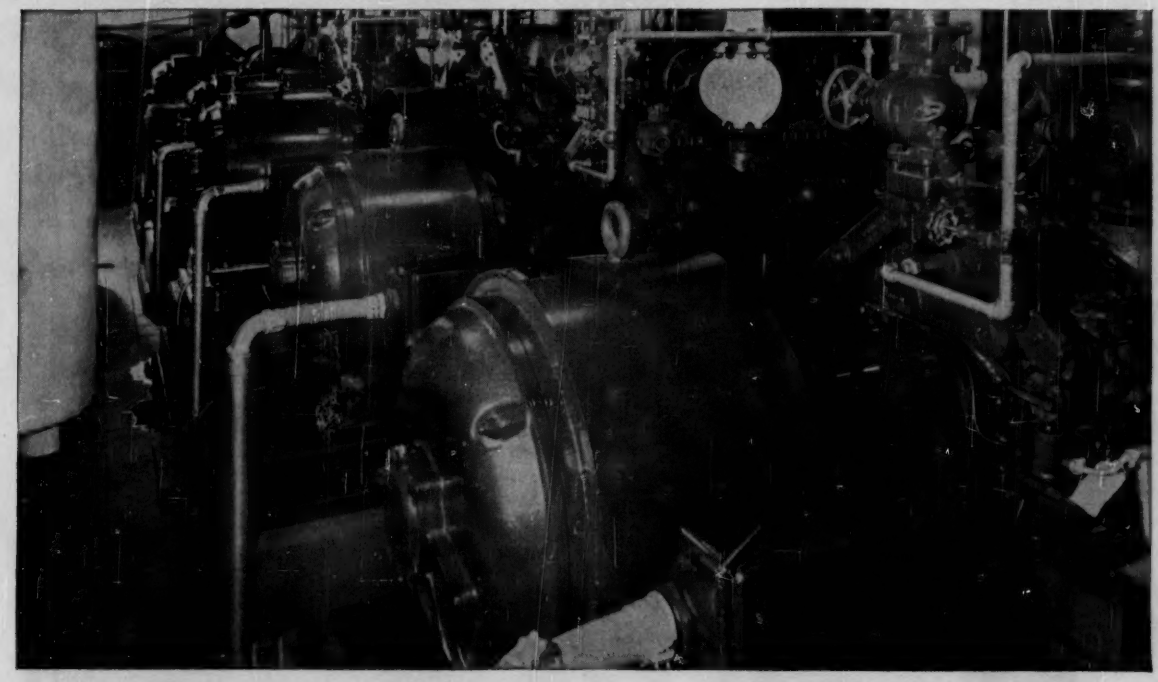
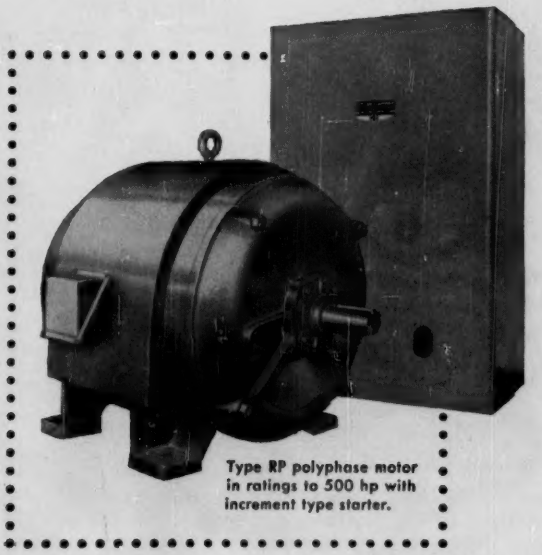


End Voltage Drop and Line Disturbance Problems caused by starting BIG MOTORS . . .



Type RP polyphase motor in ratings to 500 hp with increment type starter.

Use Wagner Increment Motor-Starter Combinations

Increment starting is the easy, inexpensive way to limit the inrush of starting current in motors up to 500 horsepower. And, you do it *best* with Wagner Increment Motor-Starter Combinations . . . polyphase open-type, totally-enclosed, or explosion-proof motors and magnetic increment starters.

Line disturbances are reduced because current taken from the line is not broken during the starting period. Motors start sure and fast . . . reach full speed in a matter of seconds. And . . . Wagner combinations cost less than motors with primary resistance or auto-transformer type starters.

Two more plusses: The compact, relatively lightweight starter is easy to connect . . . needs very little attention. The motor requires only regular inspection, cleaning, and lubrication . . . maintenance is minimized.

While 2-step combinations are suitable for most applications . . . 3, 4, 5, or 6-step increment motor-starter combinations are available for installations where unusually low inrush of starting current is required. All meet the polyphase motor-starting requirements of AEIC-EEI-NEMA.

It's possible you can save money on your big jobs with Wagner Increment Motor-Starter Combinations. A Wagner Sales Engineer will help you. Call the nearest Wagner branch or write us for Bulletins MU-128 and MU-195.

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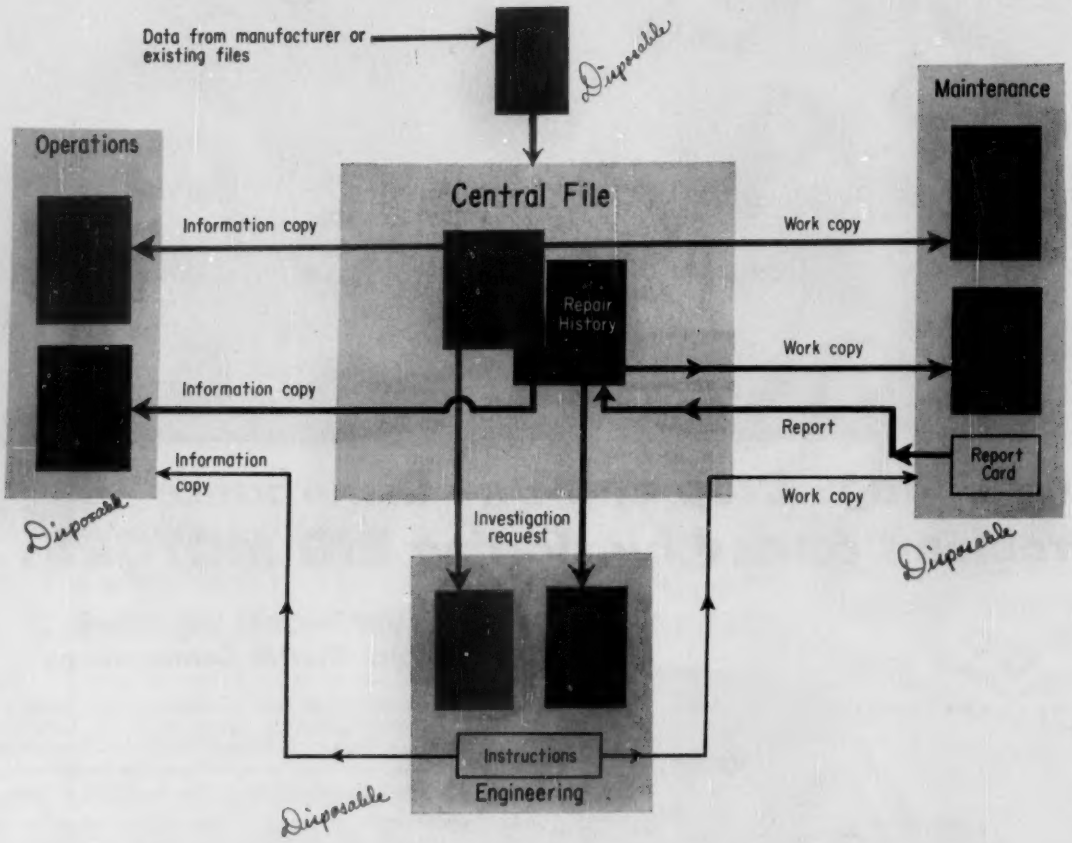


Disposable Copies of Maintenance Forms . . .

Make Record-Keeping Painless

T. W. HUDSON, Works Engineering Dept., Union Carbide Chemicals Co., South Charleston, W. Va.

Usable, accurate, up-to-date records—a problem and a chore. How do you keep them? Without a good system you're burdened with unwanted costs, unnecessary delays and excessive downtime.

In spite of this and your ability to pinpoint blame, operating and maintenance departments still accept excessive repair frequencies as part of the cost of doing business—and don't request corrective measures. When the call does go out for such corrective steps, it usually can't get efficient handling just because of this lack of complete and accurate repair histories.

How, then, do you design a record system that saves this money and keeps downtime at a minimum by revealing basic equipment inadequacies and misapplications?

Here's the Answer

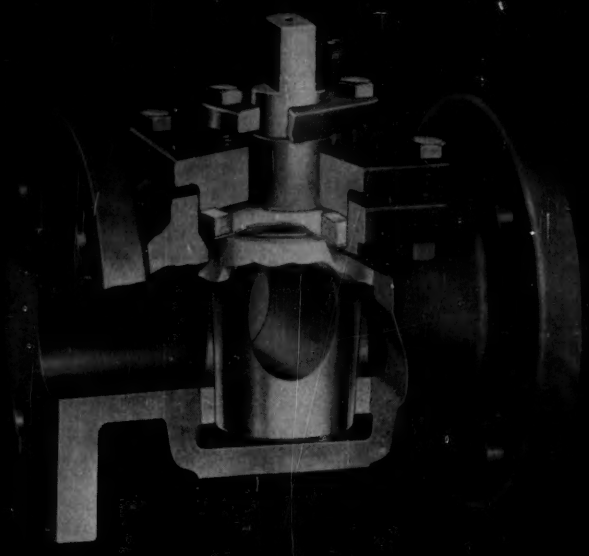
Union Carbide Chemicals Co.'s S. Charleston, W. Va., plant has

WHAT USERS SAY ABOUT THE NEW DURCO TYPE G

The new Durco Type G SLEEVELINE is a non-lubricated plug valve. A Teflon sleeve is pressed into a ductile iron or stainless steel body; a machined plug, Teflon diaphragm and gasket, a thrust collar, and a self-aligning adjuster make up the rest of this trouble-free, non-lubricated plug valve.

Available in ductile iron or stainless steel, screwed or flanged ends from ½" through 2", and in ductile iron flanged ends 3", 4", and 6", 150 psi rating.

Write for bulletin V/12.



THE DURIRON COMPANY, INC., Dayton, Ohio

sulfuric acid service

"Entirely satisfactory in service on 66°Bé sulfuric acid after 8 months."

latex user

"Valve on Latex service since May 1, has given no trouble. Other valves (gate, globe, ball, wedge, lift plug) failed because Latex build-up froze the valve."

chlorine gas service

"In service for ten months on chlorinator handling dry chlorine gas at 50 psi —ambient temperature. Formerly used lubricated valve which gave considerable trouble due to freezing."

caustic service

"Valves used on cell liquor, concentration 12%, at 160°F. After one month valve was removed and inspected. All movable parts were free, no wear was evident. Valve was reinstalled and has been in six months continuous service with completely satisfactory performance."

phosphorous user

"Used on yellow phosphorous at 160-200°F. Valves are doing fine. Thanks for a product that works—and a valve that I can turn with one hand without breaking my back."

solvent handling

"Valves performing very well on toughest solvent service after five months, where lubricated plug valves were regularly replaced due to sticking caused by leaching out of lubricant."

DURCO
CORROSION RESISTING ALLOYS & EQUIPMENT

Valves • Pump • Filters • Process Equipment

PROPERTY #* 6306-0000 UNION CARBIDE CHEMICALS CO. HORIZONTAL CENTRIFUGAL PUMP MAINTENANCE DATA FORM

Item #*

GENERAL DESCRIPTION

Manufacturer* Robbins Bros. Pumps, Inc. Type C.M. (Single Suction) Size Serial # 4825
Vendor Ditto P.O.#* Date* 12-15-48 Charge* 105
No. of Stages Dir. of Rotation‡ Cw ☐ Ccw ☐ Cust. Parts File #* Mfgr's. Dwg. # Price – Bare Pump

PERFORMANCE DATA

Cap., gpm◊ 150 Total Hd., Ft◊ 74 Hd. @ Zero Cap. Max. Cap.△ Hd. @ Max. Cap.△ Speed 1750
NPSH Req'd. @ Max. Eff. Drive HP* BHP @ Max. Eff.* Max. BHP* Perf. Curve #
Max. Working Pressure Max. Working Temp. Max. Hydro. Test Pr. 400 Psi Max. Air Test Pr. 300 Psi

MECHANICAL DATA

Casing and Suction

Suct. and Disch. Arrangement: End Suct. – Top Disch. ☐ Side Suct. – Side Disch. ☐ Top Suct. – Top Disch. ☐
Material (AISI ☐ ASTM ☐ ACI ☐) Hastelloy-D Stuffing Box 2½ deep X 2 "I.D. Gland Bolting: No. 2 Size ½" B.C. 3½
Suct. Flange Rating (ASA) lbs. Disc. Flange Rating (ASA) 300 lbs. Flange Facing Water Jacket: Yes ☐ No ☒

Frame or Bearing Pedestal

Material (AISI ☐ ASTM ☐ ACI ☐) Cast Iron Water Cooled: Yes ☐ No ☒ Lubricant: Oil ☒ Grease ☐

Bearings

Pump End: Manufacturer Arne Bearing # 300 BD
Cplg. End: Manufacturer Arne Bearing # 300 BD
Special Features

Impeller and Nut

Material (AISI ☐ ASTM ☐ ACI ☐) Hastelloy-D Type: Dbl. Suct. ☐ Sing. Suct. ☐ Open ☐ Closed ☒ Semi-Open ☐ Mixed Flow ☐
Diam. Furnished 9¼" Max. Diam. " Min. Diam. " Balance Holes: Yes ☒ No ☐ Number 4 Size ¼"

Shaft

Material (AISI ☐ ASTM ☐ ACI ☐) Hastelloy-B Solid ☐ Two-Piece ☐ Sleeved ☐ Welded ☐ Coated ☐ Brg. Spacer Sleeve: Yes ☒ No ☐
Diam. at Stuffing Box " (Not Sleeve Diam.)

Sleeve (If Used)

Material (AISI ☐ ASTM ☐ ACI ☐) # Outside Diam. " Shrink ☐ Keyed ☐ Compr. ☐ Hook ☐
Special Treatment

Wearing Rings

Casing Ring: Material (AISI ☐ ASTM ☐ ACI ☐) Hastelloy-B Suct. Nozzle Ring: Material (AISI ☐ ASTM ☐ ACI ☐) Hastelloy-B
Impeller Ring Front: Material (AISI ☐ ASTM ☐ ACI ☐) # Impeller Ring Back: Material (AISI ☐ ASTM ☐ ACI ☐) #
Type of Leakage Joint: Front– Horizontal ☐ Vertical ☐ Back– Horizontal ☐ Vertical ☐

Packing Gland

Material (AISI ☐ ASTM ☐ ACI ☐) Hastelloy-B No. of Bolts B.C. "

Packing

Mfgr. & #* Williams 815 Size 5/16" No. of Rings 7 Lantern Ring: Yes ☒ No ☐ Throttle Bushing: Yes ☐ No ☒

Recommended Clearances

Closed or Semi-Open Impeller: Front " Radial ☐ Axial ☐ Back " Radial ☐ Axial ☐
Open Impeller: Impeller to Suction Head " Impeller to Back Head "
Back Vane Height " Back Vane to Back Head "

SERVICE DATA

Mat. Handled Sulfuric acid S.G. 1.25 Visc. 2.0 (CP) Vapor Pr. @ 20°C (mm. Hg)
Operating Temp. 185 (°F) N.P.S.H. Available (ft.) Suction Pr. 160 (psig)
Solids Present: Yes ☐ No ☐ Size " Drive P.N.*

*By Purchaser ◊ Cap. and Hd. @ Max. Eff. ◆ For Water ‡ Viewed from Coupling End △ At End of Performance Curve

518-69513

operated with a record-keeping system that's quite unique and has all the earmarks of a real answer to maintenance paperwork headaches.

Operation is simple: master data and repair history forms that never leave a central file room; a commercial instant-copy duplicating machine used to reproduce the master forms for distribution; and temporary equipment repair report cards for maintenance groups to report type of failure and method of repair to the central file.

For every job, maintenance receives a copy of the master data sheets and the repair history forms. They then have all available information on the particular piece of equipment they will work on, as well as its history of operation and repair.

After the job is completed, the temporary report card is filled in and shipped off to the central

Progress Report... Primary amyl alcohol

A new alcohol with great reactivity

Do you have a five-carbon alcohol problem? If so, you may find your solution in CARBIDE's highly reactive mixed isomer, primary amyl alcohol.

CARBIDE's primary amyl alcohol consists of approximately 60% pentanol-1, 35% 2-methyl butanol-1 and 5% 3-methyl butanol-1. There are no lower molecular weight molecules, no residual chlorine, and no secondary or tertiary alcohols. That's why it is so ideal where lower volatility, greater reactivity, and increased efficiency are needed.

Primary amyl alcohol is useful as an intermediate for ore flotation reagents, plasticizers, di-ester-type lubricants, fuel and lube oil additives, resin catalysts, vinyl stabilizers, corrosion inhibitors, and surface-active agents. It can be the reaction solvent in preparation of penicillin salts, and a wash in their purification. This mixed isomer also is used as a coupler and latent solvent for nitrocellulose lacquers.

In contrast to secondary alcohols, primary amyl alcohol reacts readily with carbon disulfide and sodium or potassium hydroxide to form primary amyl xanthate . . . a powerful collector for concentrating sulfide minerals containing lead, nickel, zinc, iron, and copper.

Primary amyl nitrate prepared from primary amyl alcohol is an effective cetane improver for low cetane number distillates used as diesel fuels. It can be used to make zinc dialkyl dithiophosphates that provide corrosion resistance and antioxidant qualities for crankcase oils and transmission fluids. In heating oils, as little as 0.10 per cent primary amyl alcohol reduces burner maintenance by controlling sludge formation.

Ester-type plasticizers for vinyl chloride resins can be prepared with primary amyl alcohol. It can also be used to produce diamyl phthalate or, with higher molecular weight alcohols, to prepare mixed alcohol phthalate plasticizers.

The potential uses of primary amyl alcohol are many. For example—it deserves study for use in preparing esters of 2,4-D and 2,4,5-T herbicides, and as a spreading agent for oil-emulsion insecticides. Oil-soluble primary amyl phosphates and phosphites derived from primary amyl alcohol should be evaluated as catalysts in resin manufacture. Amines prepared from primary amyl alcohol are corrosion inhibitors, rubbers, agricultural chemicals, and surface-active agents. *And,* various esters of primary amyl alcohol lend themselves to use in perfumes and flavors.

CARBIDE's primary amyl alcohol is immediately available in tank cars or trucks, and in 55-gallon drums (carload or LCL lots). For more information, check the coupon for Technical Information Bulletin F-8517C.

PROPERTIES . . .

Purity, as Primary Amyl Alcohol, wt. %	98.0 min.
Acidity, as Acetic Acid, wt. %	0.01 max.
Carbonyl, as C_5 aldehyde, wt. %	0.20 max.
Water, wt. %	0.3 max.
Apparent Specific Gravity, 20/20°C.	0.8134
Boiling Point, °C.	
760 mm. Hg	133.1
Freezing Point, °C.	−90 (sets to glass)
Solubility in Water at 20°C., wt. %	1.7
Solubility of Water in at 20°C., wt. %	9.2
Viscosity, cps.	
0°C.	8.5
20°C.	4.3
40°C.	2.4

Tear out this coupon. Check the boxes on which you'd like more information, and mail to Dept. HE, Union Carbide Chemicals Company, 30 East 42nd Street, New York 17, N. Y.

☐ Primary amyl alcohol. F-8517C

☐ 1959 Physical Properties of Synthetic Organic Chemicals—a comprehensive description of the properties and applications of more than 400 CARBIDE chemicals.

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And remember, there is a CARBIDE sales office near you where you can obtain the services of a CARBIDE Technical Representative. His wide industry experience is backed both by extensive chemical training and by Technical Specialists.

"Union Carbide" is a registered trade-mark of Union Carbide Corporation.

UNION CARBIDE CHEMICALS COMPANY

DIVISION OF

UNION CARBIDE

CORPORATION

file. There, clerks record cause and type of failure along with corrective action taken and costs.

Beauty of the system lies in the elimination of dead ends. By its very nature, the system doesn't allow the user to "file it and forget it." Consequently, it turns out to be self-perpetuating.

How well does it work? It paid for itself in less than four months, based on reduced equipment repair costs alone.

Results Prove Success

Since its inception, over 100 pieces of equipment have been referred to engineering groups for investigation: of these 100 cases, corrective measures have been made or recommended for 70 and investigations under way on the remainder.

Typical success story with this system concerns a group of seven pumps in similar service. These pumps are equipped with mechanical seals; seal life averaged two months.

Investigations revealed inadequacies in the seal arrangement. Modifications raised average seal life to eight months.

In another instance, the repair record for a particular pump indicated repairs every three months. Study showed this pump was misapplied and, therefore, replaced with a different design. To date, the new pump has been in service ten months without repair.

Most value of the new system comes when you can break down mechanical equipment, at a single plant or location, into classes or types.

Equipment now covered includes: horizontal centrifugal pumps, reciprocating pumps, rotary pumps, plunger and diaphragm pumps, a special class of hydraulic variable delivery pumps, compressors, air conditioning units, mechanical shaft seals, steam turbines, gear reducers and certain types of electric motors.

Studies are now being made to add other types of equipment. Intention is to extend the system to all classes of dynamic mechanical equipment. Also, consideration is being given to heat exchange and distillation equipment as well as some classes of instruments and safety equipment.

Manpower requirement is small for the amount of equipment involved. One record supervisor and two clerks handle the system at present. We anticipate this will suffice for some time.

Greatest work load imposed on the record group occurs during transposition of a class of equipment from the old system to the new. At such times, the record group must carry the current work and in addition transfer all existing data and repair history from the old records to the new.

Data on Repair Cards

Cause of Failure	Type of Repair
Mechanical-Drive Steam Turbines	
Corrosion or erosion	Cleaned
Breakage	Hard face or metalize
Foreign material	Polish or grind
Galling	Remachined
Lubrication	New part
Misalignment	Welded
Wear	Adjust
Operation	Rebushed
Mechanical Seals	
Corrosion	Clean
Breakage	Hard face or metalize
Overheating	Hone, polish or lap
Galling	Remachine
Cold flow	New part
Misalignment	Weld
Normal wear	Incr. tension
Abrasion	Decr. tension
Material build-up	
Vacuum Jets and Ejectors	
Corrosion	Altered
Breakage	Cleaned
Foreign material	Polished or ground
Channeling	Remachined
Low water temp.	New part
High water temp.	Welded
Misalignment	Adjusted
Wear	Retubed
Incorrect measurement	Remarks
A. C. Induction Motor	
Corrosion	Cleaned
Breakage	Baked
Winding failure	Metalized
Heating	Machined
Lubrication	Parts replaced
Moisture	Welded
Misalignment	Adjusted
Wear	Rewind

How the System Works

The three basic forms the system is based on are shown in the accompanying illustrations.

• Master data form is printed on durable long fiber stock, sized, die cut and creased for use in a standard pocket type file. This form contains all the necessary information about the particular piece of equipment and its operating conditions.

• A temporary data form, pre-printed on bond sheet, is used for collecting detailed information for the master form. This is similar to the master form and is sent out to the vendor or manufacturer at the time of purchase.

• Repair history form consists of a code for type of failure and method of repair, a section for equipment identification and the main body of the form designed for recording details—including man-hours and material cost—of each individual repair made to the equipment.

Double check boxes allow recording, by type number, type of failure and method of repair for each major component part of the equipment.

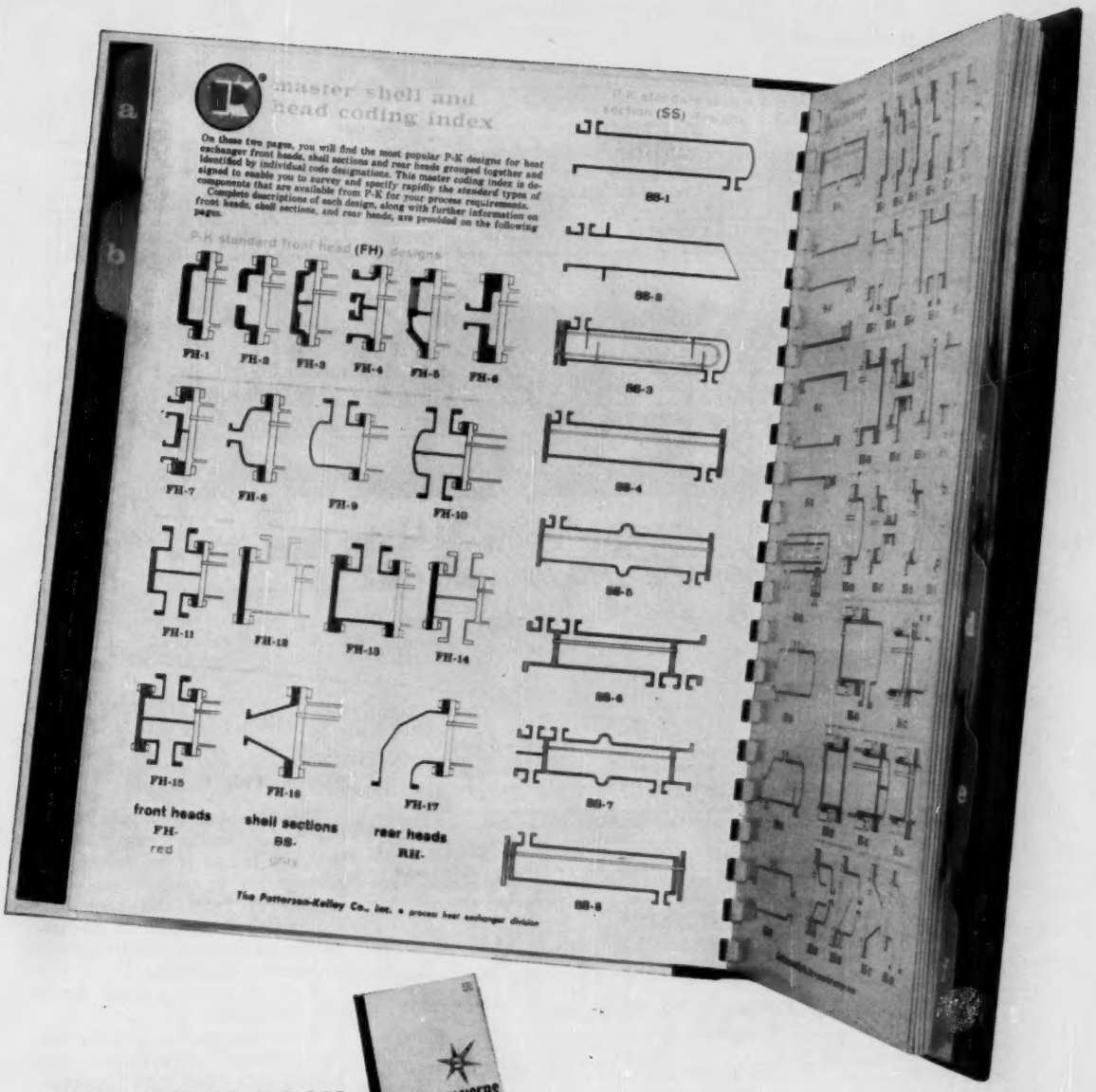
• Equipment repair report card is a 4¼ by 7¼-in. card on heavy stock to withstand rough handling in the shops or field. This card permits the repair group to report individual repairs to the central file.

Format of the records for different classes of equipment is the same but content and nomenclature differ. Previous systems indicated the advantages offered by record forms tailored for a specific class of equipment. This is in contrast to shotgun forms intended to cover a wide variety of equipment often having little in common with respect to component parts, type of failure or repair methods.

Variation in the information given on the individual forms isn't great. For some classes of equipment they are almost identical. Table on the left shows how cause of failure and type of repair vary from class to class.

Preventive Maintenance Fits In

Since the repair history form records type of failure and method of repair for each major component, there's a permanent record of just what the equipment has gone through.



NEW WORK BOOK SIMPLIFIES HEAT EXCHANGER SELECTION

The need for a standard terminology to simplify communications between P-K and engineers in the chemical processing industry has been met in P-K's new Heat Exchanger Manual.

This unique communications tool illustrates and describes components of shell and tube heat exchangers commonly used in processing. A complete system of interchangeable front heads, shells and rear heads is established. Fundamentals of heat transfer and design are reviewed. Even economic considerations are discussed. The simple, certain nomenclature saves time, effort and duplication of engineering work.

This 120-page manual, indexed and bound in hard covers, will be supplemented from time to time with new technical material. Names of holders will be registered to receive such material as it appears.

Only a limited number of copies is available and, naturally, these should go to those in the process industries who will benefit most from the information we have compiled. If you design or specify heat exchangers, write us on your company letterhead, outlining briefly areas of your interest. A few copies are available to students and non-technical personnel at a nominal charge. Patterson-Kelley Co. Inc., E. Stroudsburg, Pa.

Patterson Kelley
Heat Exchanger Division

EQUIPMENT REPAIR REPORT-HORIZONTAL CENTRIFUGAL PUMP

DISTRIBUTION: DEPARTMENT HEAD, BUILDING 176 ;327 DEPT. FILE — PROPERTY NO. 6306-0000

FAILURE (UPPER HALF OF BOX)		REPAIR (LOWER HALF OF BOX)		BLDG. 176 DEPT.
1 - Corrosion	6 - Misalignment	1 - Alteration	6 - Weld	SERVICE
2 - Breakage	7 - Wear	2 - Hard Face or Metallize	7 - Adjust	(For Details See Maintenance Data Form).
3 - Foreign Material	8 - Erosion	3 - Polish or Grind	8 -	
4 - Galling	9 - Preventive Step	4 - Remachine	9 -	INSPECTION EVERY
5 - Lubrication		5 - New Part		Wks. Mos. Yrs.

CONTROL NO.

DATE OF REPAIR	SHOP ORDER NO.	Impeller	Shaft	Shaft Sleeve	Shaft Nut	Front Impeller Ring	Back Impeller Ring	Case	Case Ring	Suction Nozzle	Suction Nozzle Ring	Pedestal	Inboard Bearing	Outboard Bearing	Slinger	MAN HOURS	MATERIAL COST	REMARKS	REPAIRED BY
1/6/59																		Pump reviewed-Bldg 179	M.G.
1/26/59		IN SERVICE - BLDG 176																Trfr. Req. #176027	ORRE
3/1/59	20146	4/4	7/2					4/4								8			Gray
5/6/59	10093	1				1		1		1			7/5	9/5		3	38.00	Entire inner surface shows slight corrosion	Lewis
9/2/59	15062	1				1		1		1			7/5					Ditto	
12/2/59	18292	1/5				1		1		1			9/5	9/5		3	168.00	Impeller badly corroded Vanes half gone	Harper
12/5/59		ENGINEERING REQUEST #82																	CHL

EQUIPMENT REPAIR REPORT, HORIZONTAL CENTRIFUGAL PUMP - PROPERTY NO. 6306 - 0000

DATE 12-3-59 CHARGE 105-4-0 SHOP ORDER NO. 18292

Repairman to indicate failure and method of repair by entering appropriate number in boxes under affected part. Make no entry under unaffected parts.

FAILURE (UPPER HALF OF BOX)		REPAIR (LOWER HALF OF BOX)	
1 - Corrosion	6 - Misalignment	1 - Alteration	6 - Weld
2 - Breakage	7 - Wear	2 - Hard Face or Metallize	7 - Adjust
3 - Foreign Material	8 - Erosion	3 - Polish or Grind	8 -
4 - Galling	9 - Preventive Step	4 - Remachine	9 -
5 - Lubrication		5 - New Part	

Impeller	Shaft	Shaft Sleeve	Shaft Nut	Front Impeller Ring	Back Impeller Ring	Case	Case Ring	Suction Nozzle	Suction Nozzle Ring	Pedestal	Inboard Bearing	Outboard Bearing	Slinger
1/5				1		1					9/5	9/5	

REMARKS: Impeller badly corroded. Vanes Half gone

REPAIRED BY: Harper — CHECKED BY: Cannon 12-3

MAN HOURS: 3 — MATERIAL COST: 168.00

REPAIR HISTORY (top) is a permanent record of failures and repairs. Report card (bottom) is used to transfer data to repair history form.

Space is provided for a control number for each component part of a piece of equipment. Control numbers are assigned on critical equipment by the person most familiar with that class or type of equipment.

When the number of similar failures of any component reaches the control number, the record clerk refers the equipment to the proper group for investigation. This is one of the key working parts of the system.

On most equipment, the control number isn't used. In these cases, an investigation is requested when, in the opinion of the operating personnel or record supervisor, the repair record shows a pattern of repetitive failure or excessive failures for the type of service the equipment is placed in.

This, as you may recognize, is the basic information for setting up and running a preventive maintenance program.

Follow This Example

This system functions from the "cradle to the grave" and is best illustrated if we follow the records on a specific piece of equipment from the time it's requisitioned through an investigation as a result of frequency or number of repairs.

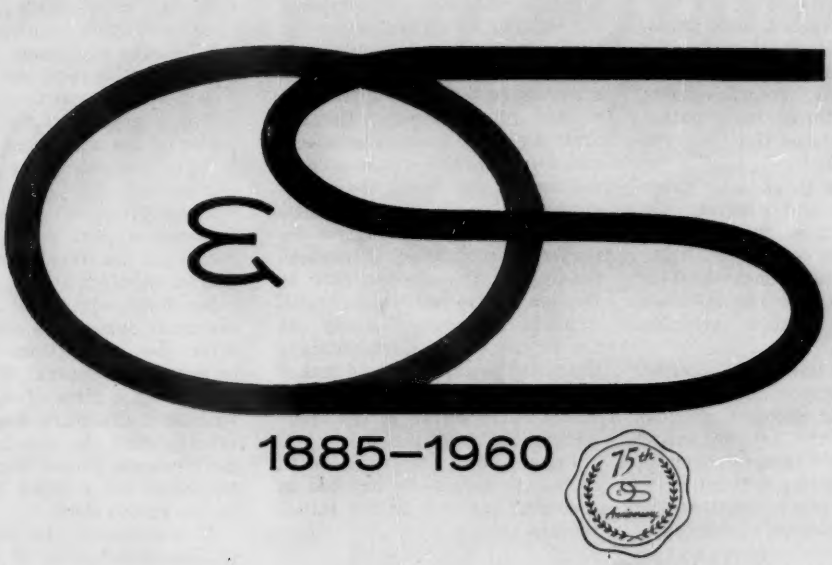
We'll use a centrifugal pump as an example.

When the pump is ordered, the requisitioner forwards the temporary data sheet with the requisition.

If the property or item number of the pump is assigned, the requisitioner enters this information on the otherwise blank form. If this information isn't available, it's entered by the purchasing department along with the purchase order number.

Purchasing department forwards the form, along with the purchase order, to the vendor. The purchase order stipulates the vendor (or manufacturer) shall complete and return the form and the purchase order is considered open (no invoice can be cleared) until the completed form is returned.

On receipt, the purchasing department forwards the completed



An Anniversary... and a Promise

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We are grateful for the skills and sense of responsibility of our engineers and craftsmen, working in the solid tradition of one of America's first metalworking centers. They have met the needs of industry through the years, and developed O&S products to a high degree of reliability and performance.

We don't feel old. We feel younger and more capable than ever, and we make this promise to our friends and customers: We will never rest in our efforts to produce the finest, most advanced boilers and fuel burning systems that it is possible to build.

A. W. Klein
President

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O&S FUEL BURNING SYSTEMS

form through routine channels to the central file.

There, the record clerk transposes the information to the master data sheet; initiates the master repair record sheet; places both forms in a pocket folder; and places the folder in the proper file.

Folders are indexed by property number and different file cabinets are used for each different class of equipment.

The temporary data sheet is forwarded to the requisitioner for checking against purchase specifications.

When the pump is received and put in service, the file clerk is advised and makes a suitable notation on the repair record sheet, using a space normally used for recording a repair.

When the pump requires repair, the maintenance group notifies the file clerk by phone and he makes copies of the master data sheet and master repair record and forwards the copies to the repair group.

Repair group makes the necessary repairs using the data sheet copy as reference material. On completing the work, the repair group fills in the repair report card and forwards it to the file clerk.

Repairman in charge of the work is responsible for entering the type of failure and method of repair. Craft scheduler or timekeeper enters the manhours charged to the job and the craft supervisor checks the entries.

The repair group discards their copies of the master sheets and forwards the report card to the central file. Using the report card, the record clerk obtains material cost from the stores department and then transposes the information on the card to the master record repair card. Since he no longer has any use for it, the record clerk destroys the repair report card and makes a copy of the master repair card which he forwards to the operating department head.

Paper flow associated with successive repairs is handled in the same manner as the initial repair.

T. W. HUDSON, a native West Virginian, has been with Union Carbide Chemicals Co. in South Charleston, W. Va., since 1948. Hudson entered Carnegie Tech in 1942 and, after a stint in the Army, received a BS in mechanical engineering in 1948. Since 1952 he has specialized in mechanical process equipment and at the present time is chairman of Union Carbide Corp.'s Mechanical Equipment Committee. Hudson is a member of ASME.

How to Handle Revisions

When an investigation is indicated, the record supervisor sends copies of the master data sheet and repair record sheet to the engineering department with a request for investigation. At the same time, a flag signal is attached to the master file, indicating a request for investigation is outstanding and notation made on the master repair record. (See line seven on repair history card.)

Successful carrying out of the investigation usually includes consultation with operating, maintenance and safety group personnel. When the investigation is completed, the engineering department prepares the instructions or drawings the repair group needs to make the desired changes.

An information copy of the instructions is forwarded to the operating department. Also, sufficient copies for the repair group are sent to the record supervisor.

When applicable, a revised data sheet is prepared and the original data sheet voided.

When the record supervisor receives the instructions, he places them in a temporary file (separate from the record system proper) and changes the investigation request flag to a signal that indicates instructions covering required revisions are being held in the temporary file. Revisions aren't made until the equipment again requires repair.

When the equipment next requires maintenance, revision instructions are sent to the repair group along with customary copies of the equipment records.

After completing the revision, the maintenance group returns the report card to the central file. The record clerk copies the information on this card to the master repair history.

Normally, equipment revisions are made during the first repair after the instructions are received at the central file. However, when a piece of equipment with an outstanding request for investigation is scheduled for maintenance, proper engineering personnel are notified by phone by the record clerk.

If convenient, the equipment is inspected. Also, if possible, necessary revisions are made on the spot. Even if on-the-spot revisions aren't possible, inspection of the disassembled equipment helps the engineer arrive at the proper solution to the problem.

System Is Flexible

Setting up the system with new equipment is no problem. However, with old equipment, there is some difficulty in finding sufficient information to set up a decent record. This is particularly true of the master data sheet.

In these cases, the maintenance group enters on their copy of the data sheet, any information they can furnish by visual inspection at the time of repair. This data sheet is returned to the central file along with the report card. Information gathered this way is copied on to the master data sheet by the record clerk.

On some classes of equipment, notably compressors, you need to keep more detailed information than conveniently handled by this system. Suplementary files fill the bill here.

The major file keeps tab on major components and the supplementary file records detailed data such as adjustments, rate of wear, inspection, performance, lubrication and test information.

MODERNIZING?
PLANNING A DRYING SYSTEM?

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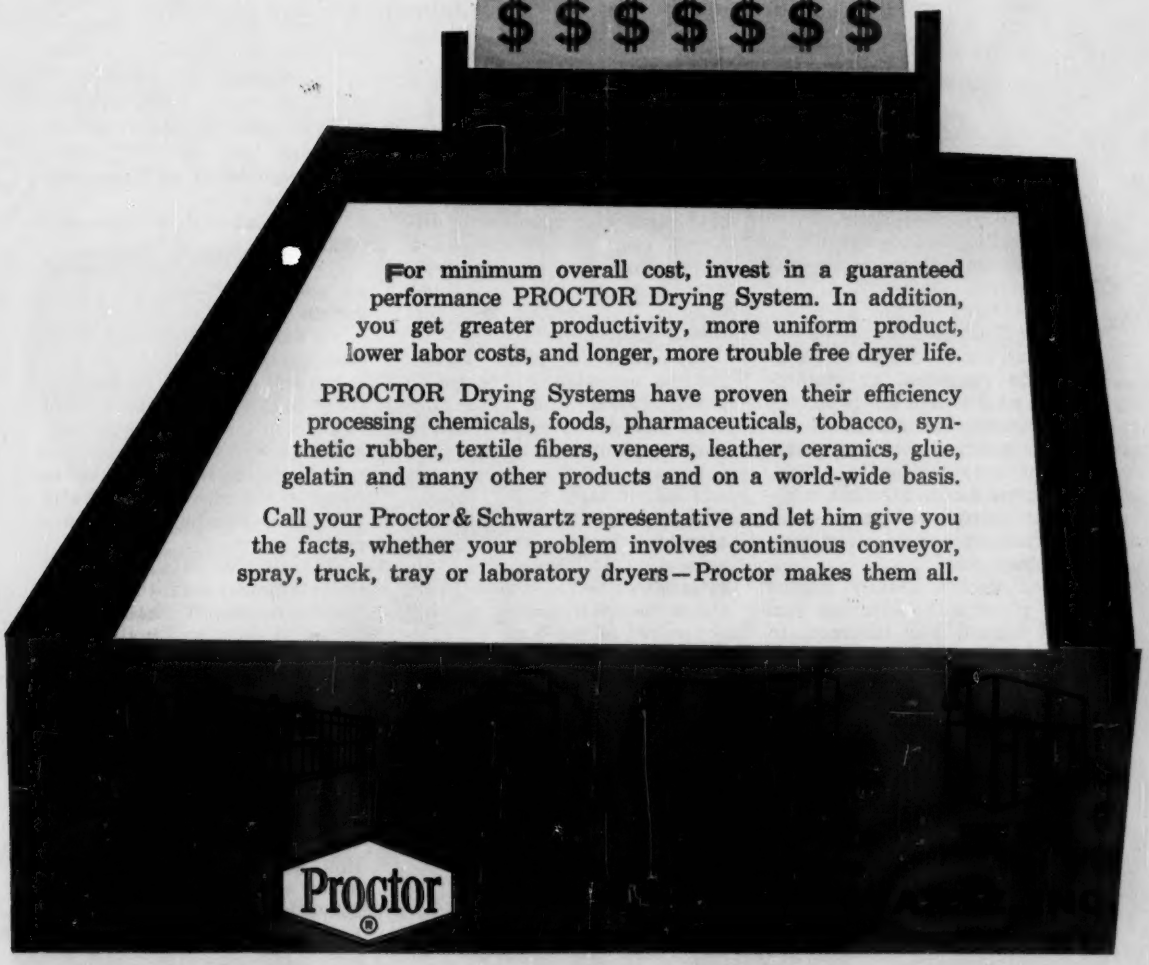

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PRACTICE . . .

CORROSION FORUM

EDITED BY R. B. NORDEN

CORROSION-CONTROL DESIGN 1

Part of a series appearing throughout 1960

Plant Site, Layout Minimize Corrosion

Proper process plant site location and layout can contribute as much, or more, to reduction of maintenance and corrosion problems as correct materials selection.

R. B. Mears, U. S. Steel Corp., Monroeville, Pa.

Designing process plants for minimum corrosion is overlooked all too frequently.

Generally, much emphasis is placed on selecting appropriate materials of construction. But usual designs do not go much further than that. Yet, good design[1] can contribute as much or more to reduction of maintenance and corrosion problems as the correct material. If design is poor, almost any material of construction will fail. With good design keyed to minimizing corrosion, a number of materials of construction may give good service.

Good design ideally begins with plant site selection and plant layout. For instance, in selecting prospective sites for new plants give some consideration to corrosivity of the local atmosphere. Plant locations only a few hundred feet from each other may have vastly different corrosive effects. In a more corrosive location maintenance costs can be several times those in neighboring, less corrosive environments.

Similarly, in plant layout, confine emission of corrosive gases, fumes and vapors to areas that are downwind of important plant structures.

We are going to discuss site and layout factors in detail.

► **Choose Good Site**—Of course, corrosion is not the only consideration in choosing an appropriate site for a new plant. Other factors include:[2, 3]

- Cost of the land.
- Taxes.
- Availability of raw materials for the plant.
- Availability of labor with the proper skills.
- Availability of transportation.
- Availability and cost of an adequate supply of water, gas and power.
- Ease of distribution to customers.

But effect of plant location on corrosion of structures and equipment is not generally given much consideration. Yet relatively small differences in plant site location can greatly affect subsequent maintenance costs.

Quantitative data to support this statement are rather scarce. However, there are several series of data which illustrate the point.

► **Keep Plant Back**—The International Nickel Co. operates two atmospheric corrosion test stations near Kure Beach, N. C. One is only about 80 ft. from the high tide level and the other is back about 800 ft. This is not a very great difference in location, yet rate of corrosion of most structural materials is several times greater at the 80-ft. location. Typical data for

Future Articles

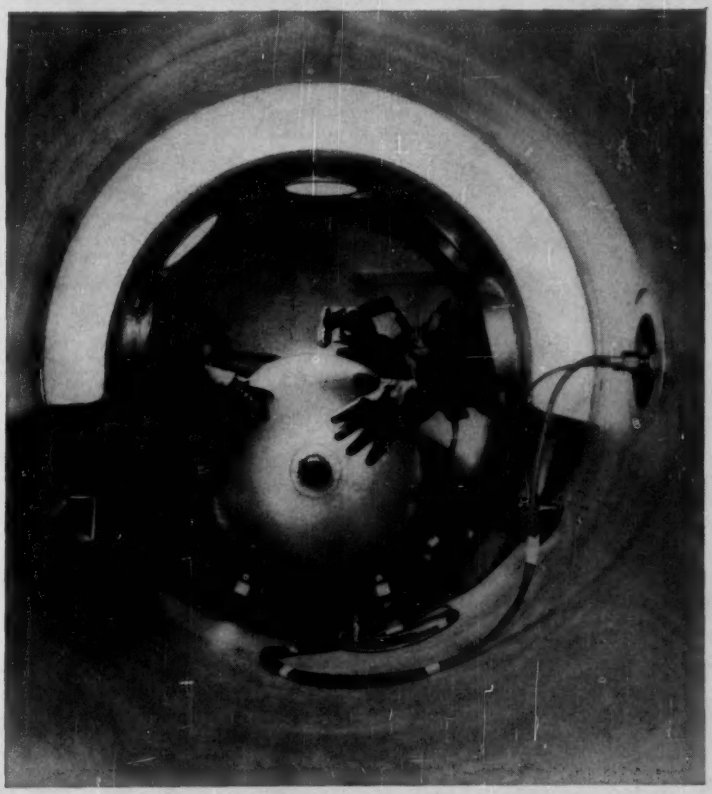
General equipment design factors.
Reducing corrosion in reactors with proper design.
Valve design for severe corrosive service.
Design of heat exchangers to minimize corrosion.
Design of mixers to minimize corrosion.

HAYNES ALLOYS

RESEARCH REPORTS

Developing new metals and improving current ones to combat the devastating effects of high heat, corrosion, erosion, and abrasion, are the primary objectives of the advanced Research and Development Laboratories at Haynes Stellite Company. HAYNES Tantalum, described below, is one of their more recent achievements. Others will be described in future Research Reports.

Design engineers, metallurgists, and physicists may see in these new metals and alloys opportunities for a breakthrough in applications where limited properties of other metals have presented obstacles. Our research scientists, engineers, and technicians will gladly help you discover whether they can help improve your products.



HAYNES Tantalum

Close to 100% pure, chemically. It is produced by the consumable-electrode process. Practically inert to a wide variety of corrosive media, with these added advantages: *Wide* sheets with improved welding characteristics, making it easier to use in chemical and pharmaceutical equipment where corrosion and product contamination must be minimum. Pictured is tantalum reactor liner being welded inside tank of inert gas.

LARGEST Tantalum Lined Reactor

An outstanding example of what can be accomplished with the greater sheet width and improved welding characteristics of HAYNES Tantalum is shown above. The vessel—the largest tantalum-lined reactor ever constructed—is a 30-gallon unit designed to operate at 630 deg. F. and 500 psi. Every part that will be exposed to corrosives, including the agitator, is made, or sheathed with, HAYNES Tantalum. For full details on this new material, write for descriptive booklet.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

Kokomo, Indiana

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Address inquiries to Haynes Stellite Company, 420 Lexington Ave., New York 17, N. Y.

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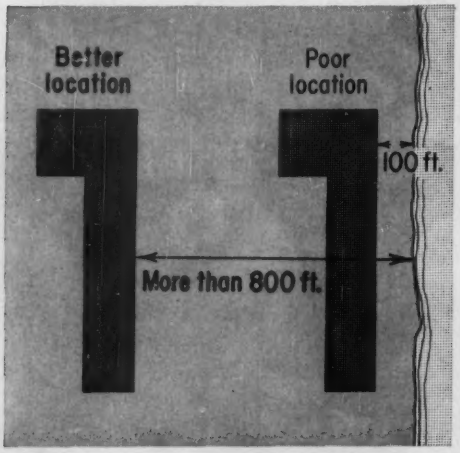
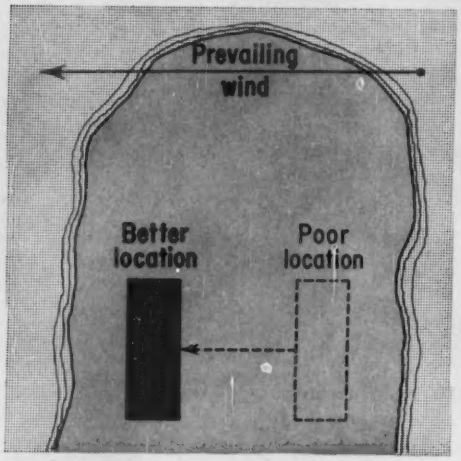
Keep Plant Back From Shore Line—Table I



Metal or Alloy	Duration of Exposure (Years)	Corrosion, Mils/Yr. 80 Ft. From Shore	800 Ft. From Shore
Ingot iron	2	29	3
Cast iron	1	23	12
Structural steel	1.5	12	1.2
Copper-bearing steel	1.5	4.7	1.0
Type 430 S.S.	2	0.01	0.003
Type 302 S.S.	2	0.006	0.002
Zinc	1	0.4	0.2
Monel	5	0.021	0.011
Inconel	5	0.0014	0.0003
Aluminum (1100–H14)	2	0.085	0.004

All tests at Kure Beach, N. C.

Sea Winds Severely Attack Many Metals— Table II



Metal or Alloy	Corrosion Rate, Mils/Yr. Wind From Land (Key West, Fla.)	Wind From Sea (La Jolla, Calif.)
Copper (tough pitch)	0.021	0.050
Tin-Bronze (Cu 92%—Sn 8%)	0.028	0.091
Aluminum (6051–T4)	0.003	0.036
Nickel	0.004	0.006
Zinc (prime western)	0.026	0.067

Data from "Symposium on Atmospheric Corrosion of Non-Ferrous Metals," ASTM 1955, based on 20 yr. experience.

several common materials are given in Table I.[4, 5, 6]

These results imply that for any plant located near the sea, a relatively small increase in distance of the plant site from the shore line can greatly reduce plant maintenance costs due to corrosion—perhaps reducing them to only ½ or ¼ of what they would be if the site were closer to the shore.

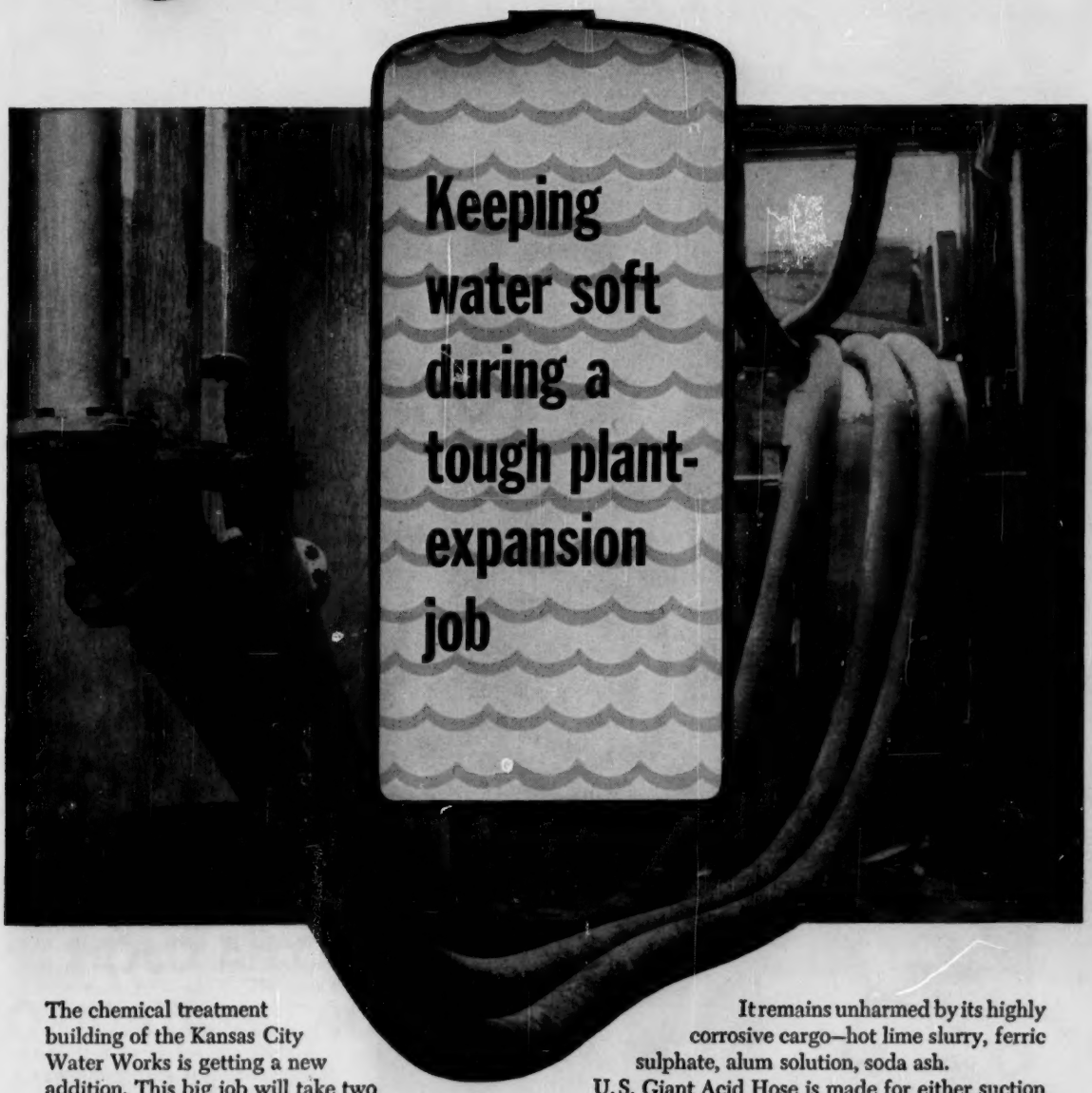
Another series of tests illustrating the same point have been described by Ambler and Bain.[7] These were carried out in Nigeria at a number of locations at various distances from the open sea. Corrosion rate of iron or steel exposed 1,300 yards from the shore is less than ⅒ that of similar materials exposed 50 yards from the shore.

▶**By Sea or Land**—A more specialized case is shown in Table II. For plants located on peninsulas extending out into the sea, it will reduce maintenance costs to locate the plant near the lee shore rather than on the windward shore. Data supporting this statement are not conclusive, although most corrosion engineers have observed much qualitative evidence that supports it. Possibly the most direct evidence comes from the experience of ASTM Committee B-3, Sub. VI, with its corrosion test site at Key West, Fla. Although this test site was fairly close to the seashore, corrosion rates of many metals were much lower than at La Jolla, Calif.

Main reason for lower rates at Key West: prevailing wind is from the land whereas at La Jolla, it comes from the sea. Typical results from Committee B-3 tests are presented in Table II.

The above examples relate to seacoast exposure. There are

US RUBBER GIANT ACID HOSE



Keeping water soft during a tough plant-expansion job

The chemical treatment building of the Kansas City Water Works is getting a new addition. This big job will take two years, during which time the building contractor is using a simple and economical means for conveying water-softening chemicals to the water supply.

He uses chemically-resistant U.S. Giant® Acid Hose, furnished with stainless-steel fittings.

The men find it extremely flexible and easy to handle, resistant to abrasion, impact and weather.

It remains unharmed by its highly corrosive cargo—hot lime slurry, ferric sulphate, alum solution, soda ash.

U.S. Giant Acid Hose is made for either suction or discharge service, replacing metal pipe because it handles highly corrosive solutions so well.

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Polluted Atmospheres Work Metal Havoc—Table III

Metal or Alloy	Corrosion Rate, Mils/Yr. Unpolluted Atmosphere (State College, Pa.)	Industrial Atmosphere (Altoona, Pa.)
Copper (tough pitch)	0.0171	0.0546
Tin-Bronze (Cu 92%—Sn 8%)	0.0127	0.0883
Brass (Cu 85%—Zn 15%)	0.0176	0.0741
Nickel (99% + Ni)	0.0085	0.222
Zinc (prime western)	0.0433	0.266
Monel	0.0067	0.0756

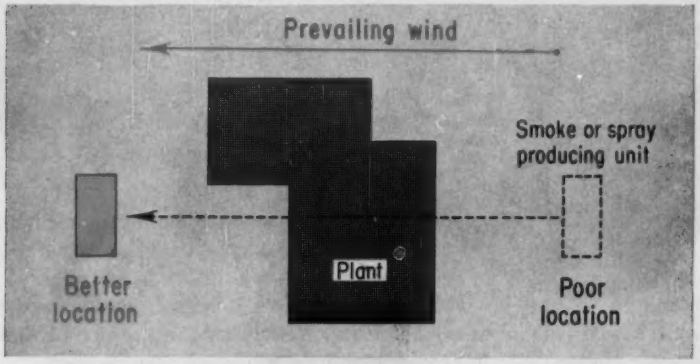
Data from "Symposium on Atmospheric Corrosion of Non-Ferrous Metals," ASTM, 1955.

Marine-Industrial Atmospheres Cause Severe Corrosion—Table IV

Metal or Alloy	Corrosion Rate, Mils/Yr. Marine-Rural	Marine-Industrial
Aluminum alloy (3S)	0.03	0.6
Steel	1.4	3.5
Zinc	0.1	1.0
Magnesium (AZ 80)	0.4	3.7

Data based on 2-yr. exposure

Plant Layout: Keep Fume Producers Downwind



also great differences in the corrosiveness of different inland locations. Some of these differences are the result of variations in weather and climate at various geographical locations but many are the result of atmospheric contamination by human activities.

▶**Climatic Variations**—As might be expected, corrosion rates are low in warm, dry (desert) atmosphere and also in locations where temperatures are consistently below the freezing point.

However, probably no one would locate a plant in the middle of the Sahara Desert or in Antarctica just to escape corrosion problems. Of more practical importance are wide variations in corrosivity resulting from relatively small changes in location.

In temperate climates there frequently is a considerable difference between the time a surface stays wet if it is located in a river valley, as compared with the time it remains wet if it is exposed just a mile or two away but up on a hill. Fog frequently clings to valleys but dissipates readily on hills. Under such conditions, structures located in the valleys may corrode several times as fast as those on adjacent elevations.

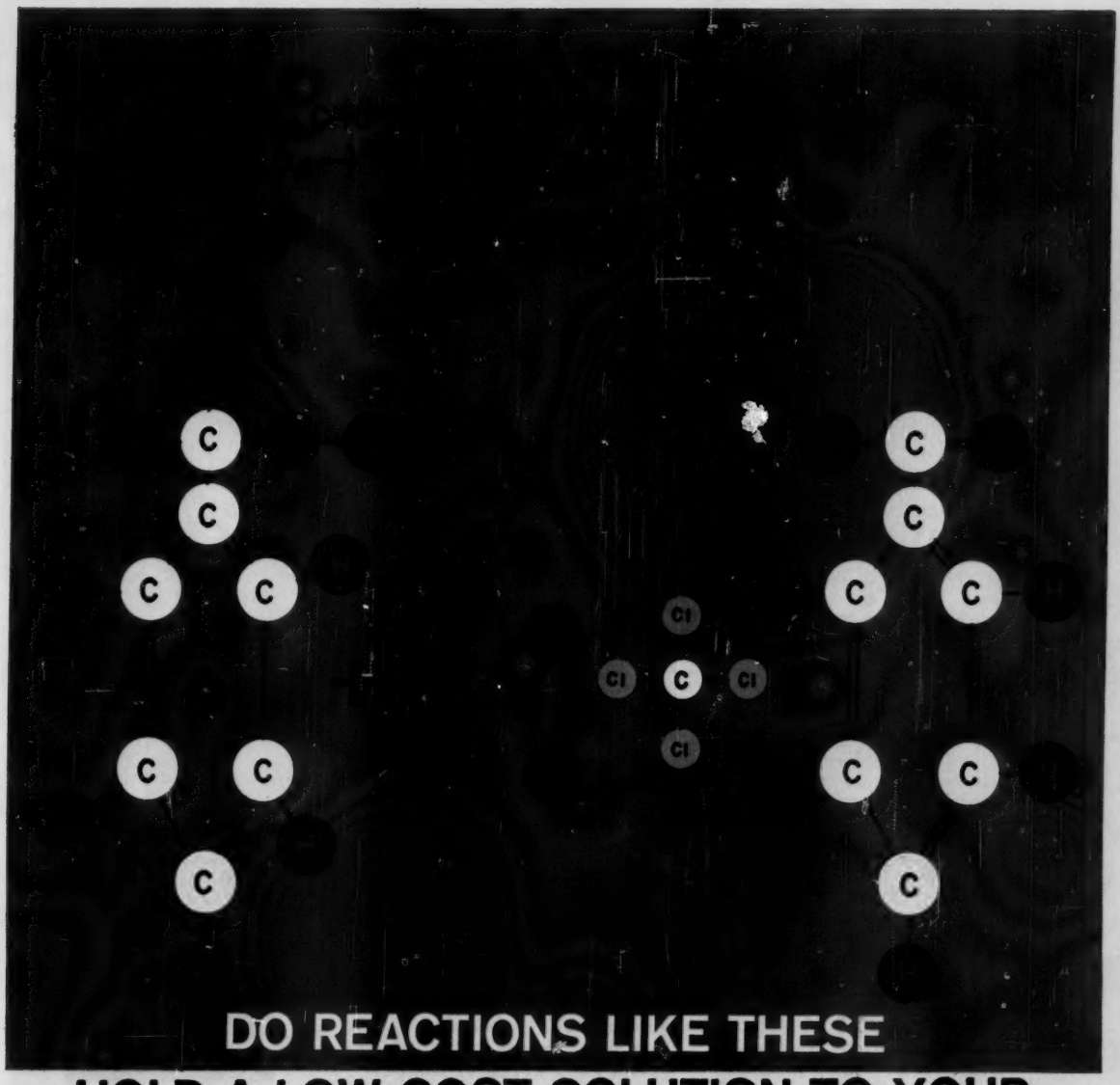
Anderson[8] states that zinc, exposed at a shaded location near a stream, corrodes faster than when exposed in an open location on a hill just a short distance away. Probably the same is true for many other metals, although data are lacking on this point.

▶**Watch Polluted Air**—Industrial-air pollution can greatly stimulate corrosion. Perhaps the most convincing data to illustrate this point were obtained by ASTM Committee B-3, Sub. VI. This committee exposed samples of many nonferrous metals and alloys both at Altoona, Pa. and at State College, Pa. These locations are only about 33 mi. apart and climatic conditions are very similar at both. But in Altoona there is considerable industrial activity with correspondingly greater atmospheric pollution.

Results of corrosion tests at the two locations are given in Table III. Note that corrosion rates at State College are only ¼ to ⅛ those at Altoona.

A separate series of tests on galvanized steel specimens was carried out at both Altoona and State College by ASTM Committee A-5, Sub. XIV. They found[9] that galvanized sheets, with a coating weight of 1 oz./sq. ft. developed first signs of rust after 2½ yr. exposure at Altoona. But only after 12½ yr. exposure at State College was rust first visible. In other words, for galvanized sheets, Altoona was five times as corrosive as State College.

Gibbons[10] has reported on corrosion rates at two sites in Halifax, Nova Scotia. One is a



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HOLD A LOW COST SOLUTION TO YOUR OXIDATION PROBLEMS?

Allied Chemical Nitrogen Tetroxide is a low-cost oxidant. It can be used in the wood pulping, rubber, metal recovery, and lubricant purification industries, and for many other applications. Perhaps this versatile chemical can solve some of *your* oxidation problems.

See the box at right for further reactions. For further information and application data on Allied Chemical Nitrogen Tetroxide, write for Allied Chemical's 59 page product bulletin "Nitrogen Tetroxide".

Allied Chemical's Nitrogen Tetroxide is shipped in tank-cars, one-ton cylinders, or 125 and 150 pound cylinders.

NITROGEN TETROXIDE CAN BE USED AS A LOW COST OXIDIZER:

- ... At very low temperatures in the form of solutions, such as NO in N_2O_4
- ... In concentrated liquid form from −11° to 21°C
- ... In acids such as sulfuric and nitric
- ... As a gas in form of NO_2 at elevated temperatures
- ... As a solution in carbon tetrachloride or chloroform from 0° to 30°C for such oxidation reactions as
  - Aromatic alcohols to aromatic aldehydes;
  - Alkyl aryl carbinols to ketones;
  - Alcohol groups in starch or cellulose to carboxyl groups;
  - Thiols to sulfonic acid.

For specifications and local offices, see our insert in Chemical Materials Catalog, pages 475 - 482 and in Chemical Week Buyers Guide, pages 37 - 44.

BASIC TO AMERICA'S PROGRESS

2819

NITROGEN DIVISION

Dept. NT13-5-2, 40 Rector Street, New York 6, N. Y.

Key Design Points for Minimizing Corrosion

1. Keep plant back from shoreline. A difference of 700 ft. can cut corrosion of plant structures by 70%.
2. Locate plant near lee shore of peninsulas, rather than at the windward shore, to reduce corrosion.
3. Select plant site up on a hill rather than in a valley, if possible, since fog clings to valleys.
4. Locate a structure in a nonindustrial area to avoid corrosion from polluted air.
5. Layout plant to locate stacks emitting corrosive gases downwind from the major portion of plant construction. This will avoid possibility of corrosive "rain" falling on buildings and equipment.

marine industrial site located on the roof of the Halifax Federal Building in the downtown area of the city, two city blocks from the harbor. The second one is a rural, marine site lolated on the east coast approximtaely 7 mi. from Halifax. It is at an elevation of 100 ft. and 300 ft. from the ocean. Some results are given in Table IV.

These data are interesting since they show effect of industrial activity in accelerating corrosion in a marine environment. Both test sites were fairly close to the sea and both were at a rather similar elevation, one on a building and one on a small hill. Yet corrosion rates are vastly different.

Gibbons also presents the average sulfur dioxide concentration in the two atmospheres. There was an average over the 2-yr. period of 12.52 mg. SO_3 in the "Marine-Industrial" location and only 0.48 mg. at the "Marine-Rural" location in Halifax. This can be taken as a measure of industrial activity in the two locations.

Other factors being the same, it would be advantageous from a maintenance standpoint to locate a structure in a nonindustrial area rather than in a region where there is considerable industrial activity.

▶**Plant Layout**—Now let us assume that we have decided on our plant site, taking account of geographical and climatic conditions that will favor reduced maintenance. The plant layout we choose can also greatly affect subsequent maintenance costs. If, as part of the plant operation, corrosive gases, fumes or vapors are emitted to the atmosphere, it is obviously to our advantage to locate the point of emission downwind, with respect to any prevailing wind, from the bulk of our plant construction.

In much of the United States prevailing wind is from the west. Therefore, from a plant maintenance standpoint it is advantageous to emit gaseous corrosive products to the east of any construction.

As an example, in coke plants it is common practice to quench hot coke by spraying plant water on it. Water changes to steam as it hits the hot coke and this steam, containing entrapped droplets of quench water, is carried up into the atmosphere in large towers.

▶**Rain Corrodes**—Eventually much of the condensed steam and entrapped water falls on the area just downwind from the quench tower. If structures are in this area, they are almost continuously wet by this rain.

If the quench towers are located downwind from major plant structures, maintenance costs will be greatly reduced. See the drawing on p. 148.

Maintenance costs resulting from atmospheric corrosion of buildings and structures in a large plant are not minor items.

At a large chemical plant located in the southwest, paint maintenance costs alone average over $1-million/yr.[11] Within this plant, corrosion rates of bare steel vary from 2.7 mils/yr. to over 27 mils/yr. depending on location within the plant area. Distance from the coast, direction of the prevailing wind and location of equipment from which corrosive fumes are emitted all contributed to these corrosion rates. It seems probable that with optimum plant location and layout, such high maintenance costs could be reduced to less than half.

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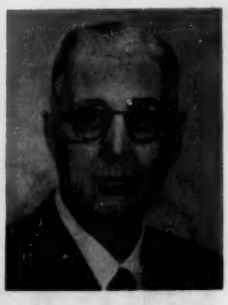
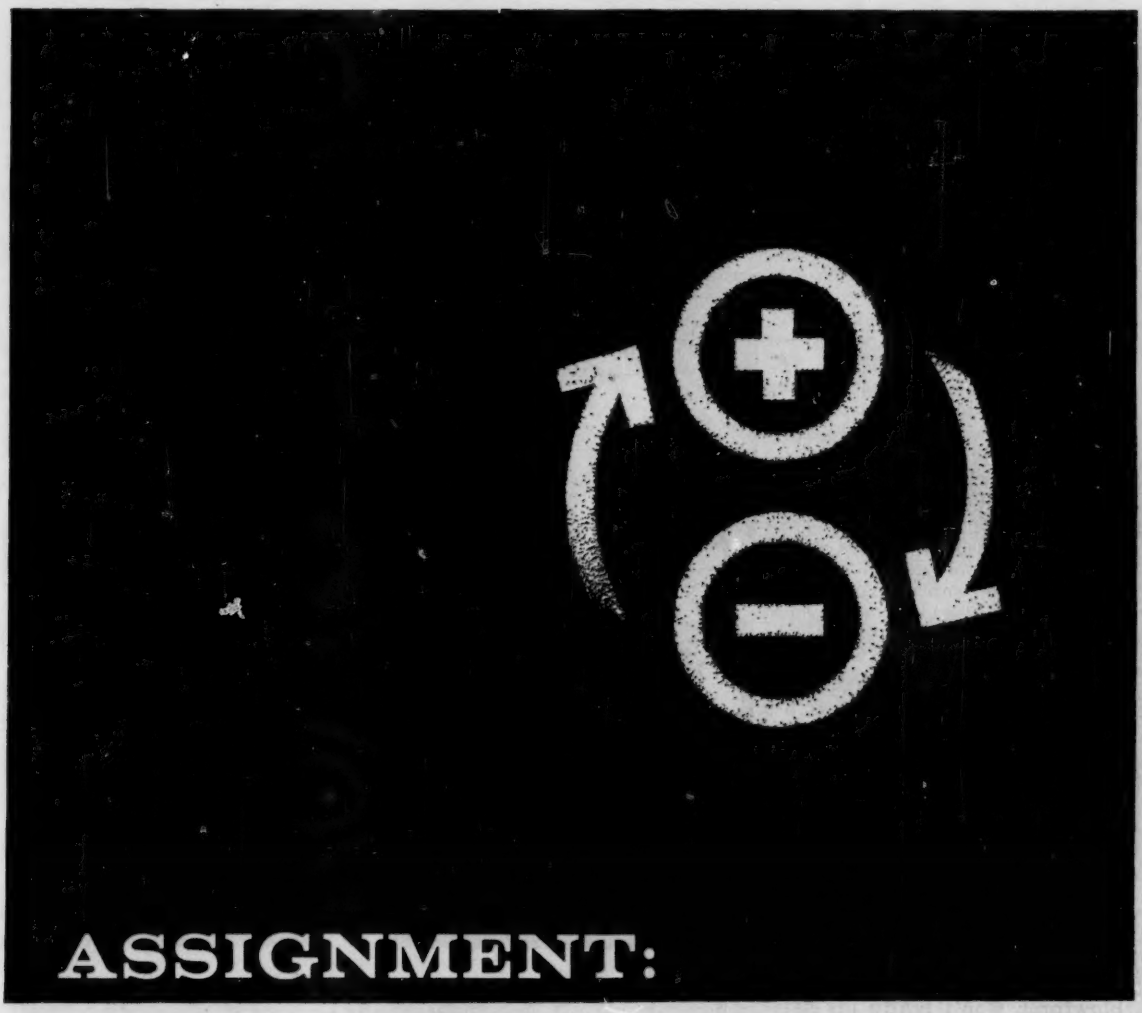
10. Gibbons, E. A., "Report by Sub-Committee C, Atmospheric Corrosion Testing," National Research Council of Canada, Feb. 24, 1959.
11. Cannon, R. E., *Chem. Eng.*, Feb. 10, 1958, p. 125.

Data for Table I was kindly supplied by T. P. May of Inco and C. P. Larrabee of U. S. Steel.



ROBERT B. MEARS is director of the Applied Research Laboratory, United States Steel Corp. He is past president of the National Association of Corrosoin Engineers and was given the Whitney Award in the Science of Corrosion at the 1949 meeting of NACE. He is also a member of American Institute of Mining and Metallurgical Engineers, American Society for Metals and Electrochemical Society. He is the author of a number of technical papers and several patents.

Dr. Mears graduated from Penn State in 1928 with a BS in electrochemical engineering. He was a member of the technical staff of Bell Telephone Laboratories until 1932 when he went to England to study under Ulick R. Evans at Cambridge. This work led to his obtaining a PhD in metallurgy from Cambridge Univ. in 1935.



ASSIGNMENT: CORROSION

How Lukens *Application Research* can help you find the right steel plate for the job

Migrating ions—superimposed on a photomicrograph of corroded steel plate—symbolize one of metallurgy's oldest assignments: the battle against corrosion. Developing new tactics in this constant campaign is the job of our Application Engineering staff.

For example, called on early in the planning stages, Lukens engineers recently attacked almost identical problems for two large processing companies—and came up with two completely different solutions.

The first involved a sugar refiner's vacuum pans. Frequent and costly cleaning was required to head off corrosion and product contamination. Our staff's prior research and experience in the food equipment field led it to suggest *nickel*-clad steel for the pans. (13% and 8% nickel-clad on A-285 backing steel.)

Cleaning and maintenance were equally costly to a leading chemical and dye company—in the protection of its nitrogen solution barge tanks. Here, our engineers found *stainless*-clad steel the most desirable answer. (12% 304L on A-212 backing steel.)

Armed with practical as well as technical knowledge of Lukens' wide range of special-duty steels, our Application Engineers have helped conquer corrosion on many fronts. That's why we say . . . *if your assignment is corrosion, let it be our assignment, too.* Contact Manager, Application Engineering, **H-10 Services Building, Lukens Steel** Company, Coatesville, Pa.

Helping Industry Choose Steels That Fit The Job

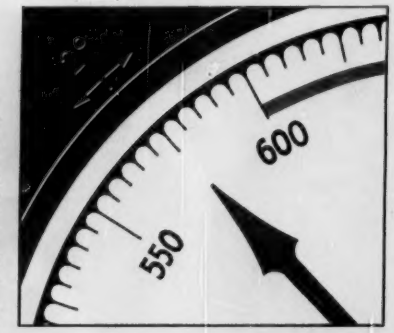
LUKENS

ASK FOR THE BULLETIN ON LUKENS CLAD STEELS

AROCLOR SYSTEMS DELIVER STEADY PROCESS HEAT TO 600°F and . . .

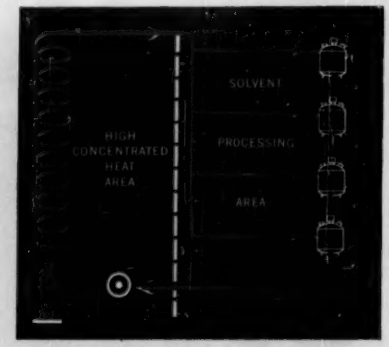
PINPOINT HEAT CONTROL...

to within 2° F. Indirect heating with Aroclor 1248 ends processing problems from local hot spots and overheating. Units range from small, portable electric types to large, gas- and oil-fired heaters generating up to 20,000,000 BTU's per hour. Typical uses: cooking of alkyd resins, dyestuff synthesis and other chemical reactions, deep-fat frying and other food processing, drying ovens and molding equipment.



ECONOMY!

Unpressurized systems cost less to install and maintain than pressurized systems. Forced circulation of liquid Aroclor requires no condensers, vaporizers, traps, heavy-walled jackets or complex feed mechanisms. Compact design saves space. Heat from a single unit can be supplied for multiple uses at different temperatures. Total efficiency saves processing dollars.



FIRE SAFETY!

Even a blowtorch won't ignite fire-safe Aroclor 1248. A heating system designed with Aroclor 1248 eliminates the hazard of the vaporized, flammable fluid or danger of direct flame processing. Operating in a closed system vented to the atmosphere, these heating systems also eliminate the threat of "live" steam or chemical vapors escaping under pressure.

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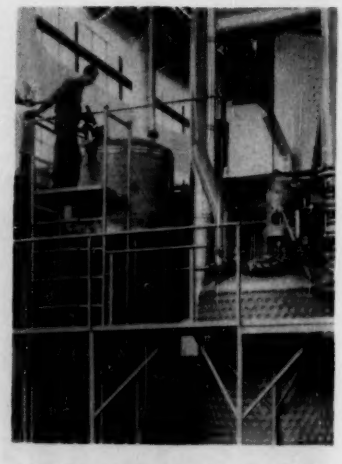
Aroclor: Monsanto T.M., Reg. U.S. Pat. Off.

(*Continued from p. 52*)

methanol - formaldehyde expansion is scheduled for completion by early 1961.

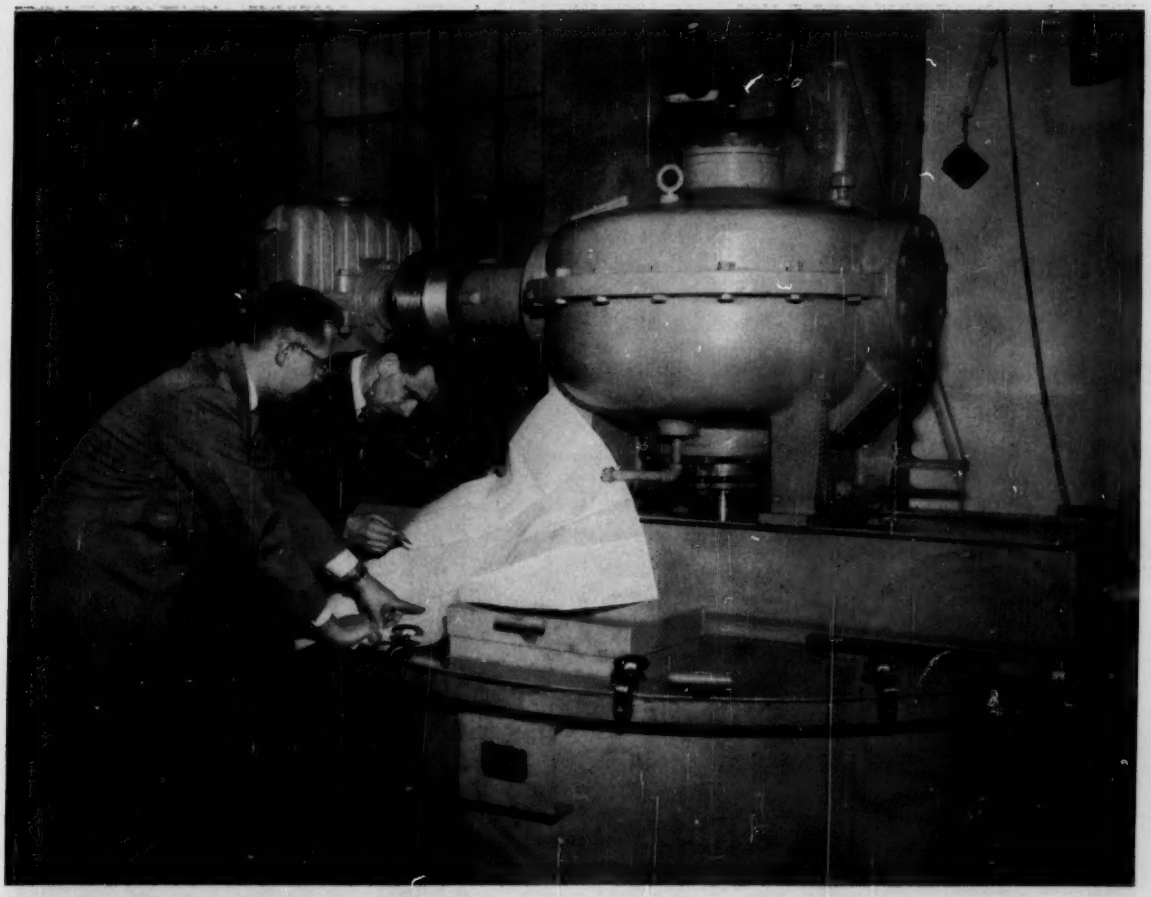
Ethyl Corp. has completed expansion of capacity for aluminum alkyl production at its Orangeburg, S. C., plant. Increased output of ethyl, isobutyl and methyl aluminum, and ethyl and methyl aluminum halides will satisfy demand for olefin polymerization catalysts.



Udylite Corp., Detroit, Mich., doubles its capacity to produce metal-finishing chemicals. Included in new production capacity is a 1,500-gal. autoclave, shown above, for high - pressure, high - temperature reactions.

SunOlin Chemical Co. plans a $15-million expansion of its North Claymont, Del., ethylene plant to near 100,000 tons/yr. capacity. Sun Oil's Marcus Hook, Pa., refinery will supply dry-gas process feed; ethylene output is destined for ethylene oxide, ethylene glycol, and polyethylene manufacture. Also at North Claymont, SunOlin's new $8-million urea plant will soon go on stream.

Stauffer Chemical Co. plans to construct a new carbon bisulfide plant on a site in Delaware City, Del., purchased from Tidewater Oil. Con-



1800 gallon grease kettle features a unique gas firing arrangement that preheats blending oils to speed processing of each batch. Vice President and Plant Manager G. H. Goring (at right) and Blaw-Knox Design Engineer W. E. Luley teamed up to create the cost cutting unit.

Buflovak job-engineered kettle handles bigger batches in less time

Since installing a Buflovak kettle, the Ontario Lubricating Company, Ltd., has stepped-up grease production, cut processing time.

Wherever used, Buflovak kettles turn in profit-building performances because they are engineered to accurately meet job requirements.

Buflovak makes many types of kettles, so their engineers can impartially recommend the best unit based on known specifications and the results of product testing. Temperature, pressure, vacuum, agitation, wall thickness, safety and economy are all carefully weighed. And when custom design is essential, Buflovak brings over 30 years of kettle know-how to the project.

Check your kettle needs at the Buflovak Customer Service Laboratory

If your process is new or untried . . . if you suspect that your operation could be improved, bring your problem to Buflovak's research lab. Here you can work with skilled engineers . . . use the latest in small scale and pilot size equipment to investigate drying, evaporation, extraction, impregnation, crystallization and other related processes.

Write for Catalog 356-R on Buflovak's Processing Kettles, Catalog 381 on the Buflovak Laboratory. Additional facts also available in Chemical Engineering Catalog, pages 429-452.

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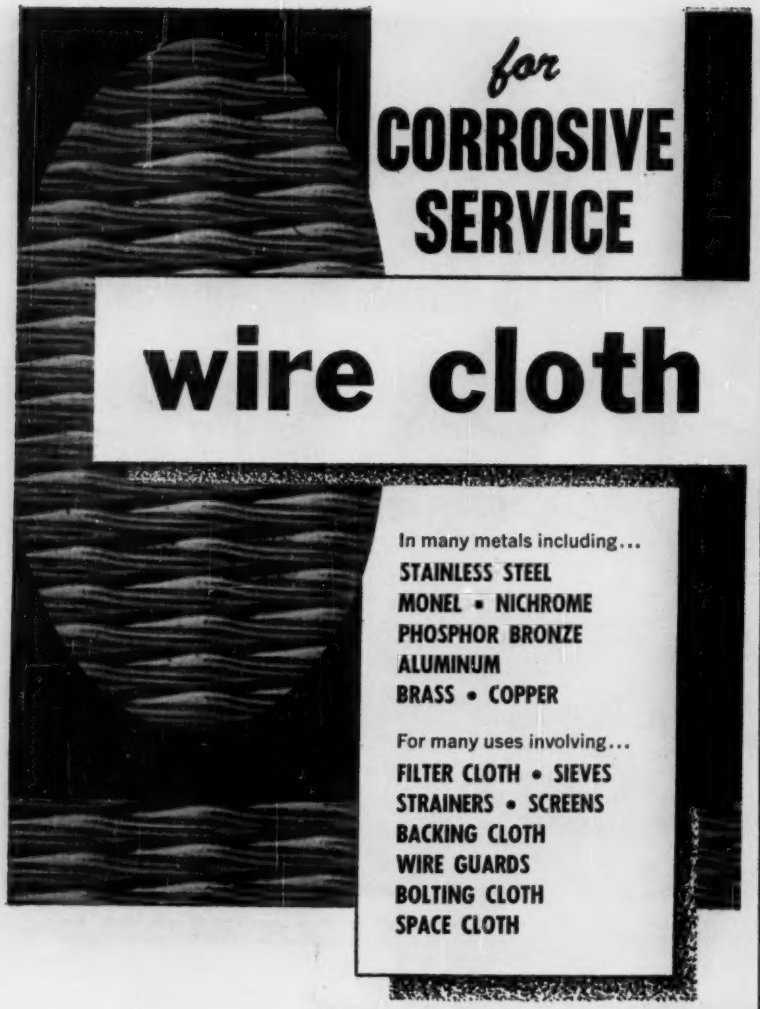
BLAW-KNOX COMPANY
Buflovak Equipment Division
1543 Fillmore Avenue, Buffalo 11, N. Y.



If you have a tough corrosion problem and need wire cloth or wire cloth parts, here's a source of supply that knows the answers. We are proud of the quality of our cloth...accurate mesh count, close tolerance wire diameter, precision weaving...plus the know-how necessary to specify the proper alloy for **your** service conditions.

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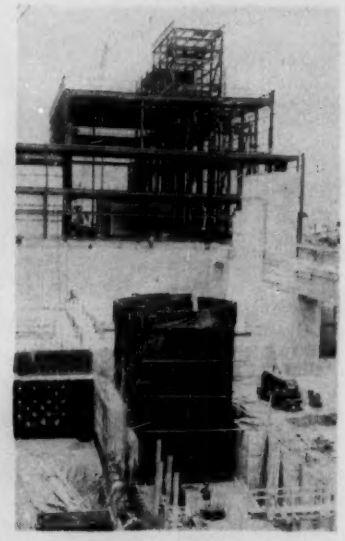
struction is scheduled for completion by fall, 1960. Plant will employ a process currently in use at Stauffer's LeMoyne, Ala., plant.



Atomics International reports progress in the installation of the Hallam Nuclear Power Reactor near Hallam, Neb. The 245,000-tkw. nuclear reactor core will soon be lowered into the cavity liner shown above; plant construction is scheduled for completion by 1962.

Fluor Corp., Los Angeles, Calif., will perform engineering, construction and equipment procurement for a 450-million-cu.-ft. natural gasoline plant at Vermillion Parish, La. Union Oil Co. of Calif. and Goliad Corp. of Houston, Tex., awarded Fluor the contract.

Canadian Chemical Co., Ltd. announces plans for a $4-million expansion of its Edmonton, Alta., petrochemical plant. Canadian Chemical produces formaldehyde, methanol, acetic acid and pentaerythritol, as well as solvents for the paint industry.

Borden Chemical Co. has completed construction of a $2.5-million pilot unit to produce 1,000-lb. batches of polyvinyl

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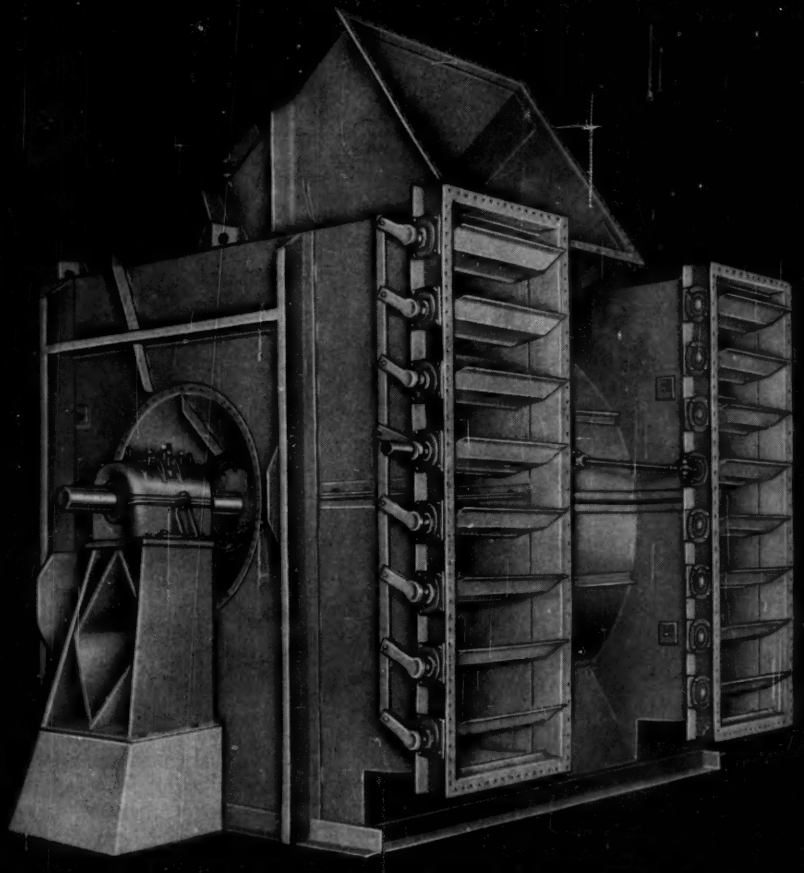

Westinghouse offers you a Heavy-Duty Fan... the right type...the right size...the right blading

Remember this: American Industry invests more in Westinghouse Heavy-Duty Fans than in any other.

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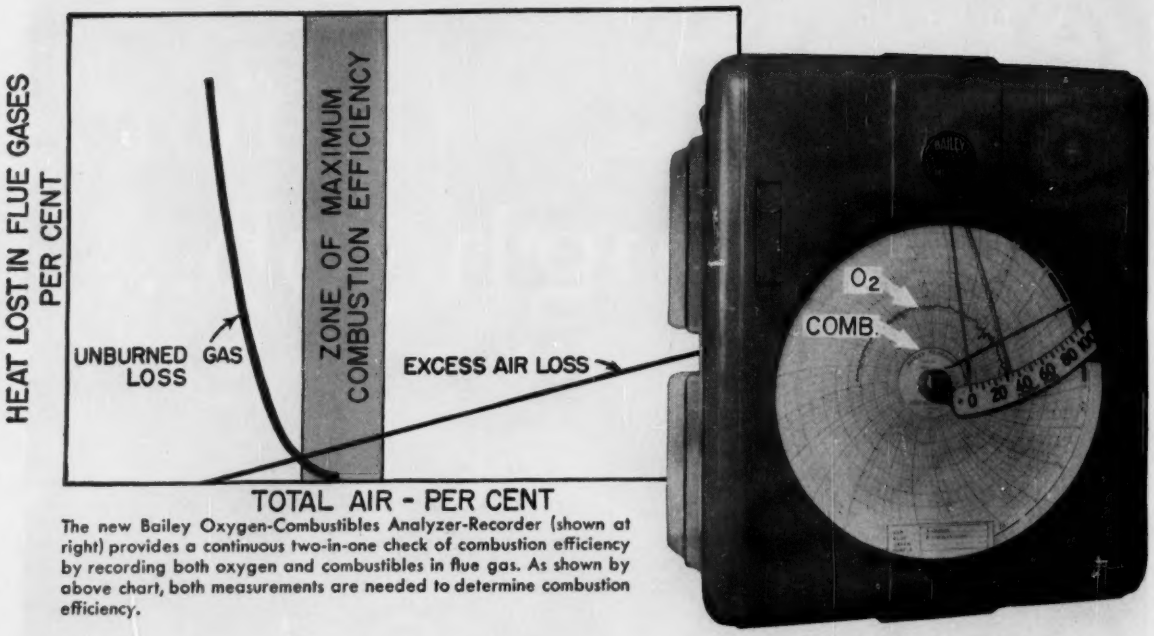

The new Bailey Oxygen-Combustibles Analyzer-Recorder (shown at right) provides a continuous two-in-one check of combustion efficiency by recording both oxygen and combustibles in flue gas. As shown by above chart, both measurements are needed to determine combustion efficiency.

BAILEY announces . . . New 2 in 1 way to measure Heater Combustion Efficiency

The new Bailey Oxygen-Combustibles Analyzer-Recorder gives you a continuing double check on combustion economy. It's fast response measures and records:

1. **Excess air**—regardless of the fuel or combinations of fuels being burned.

2. **The mixing efficiency of your fuel-burning equipment**—by indicating the amount of combustibles in your flue gas, resulting from incomplete mixing of fuel and air.

Combustion efficiency depends upon fuel-air ratio. Too much fuel can be even more costly than too much air. And because of the interdependence of these two factors, no control that measures only one of them can give you complete protection.

Now, for the first time, you can check *both* with a *single* fast acting instrument, using the new Bailey Oxygen-Combustibles Analyzer-Recorder for industrial furnaces, kilns, heaters and boilers.

Fuel economy improves as excess air is reduced —until unburned fuel begins to show up in the flue gas. When this happens, combustion efficiency drops off sharply if there are further decreases in the air-fuel ratio. That's why combustion gases must be analyzed for *both* oxygen and combustibles to get a true indication of efficiency—and that is why Bailey coordinates both measurements on the same chart, to show when excess air may be reduced safely without danger of greater losses from unburned gases.

The Bailey Oxygen-Combustibles Analyzer is an approved combustion safeguard.

Ask your local Bailey engineer for suggestions on application. Equipment details in Product Specifications E65-1 and E12-5. CP107-1

Chemical and petroleum division

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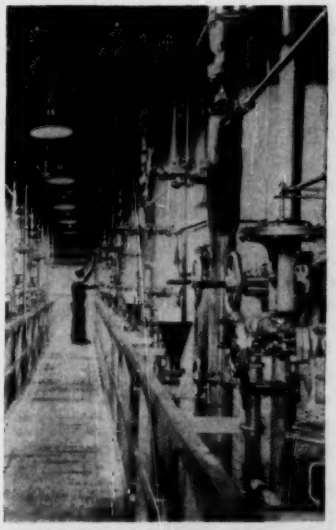
alcohol, polyvinyl acetate, acrylics and butadiene-styrene. Borden also reports headway in construction of commercial-scale capacity for polyvinyl alcohol and butadiene-styrene production.

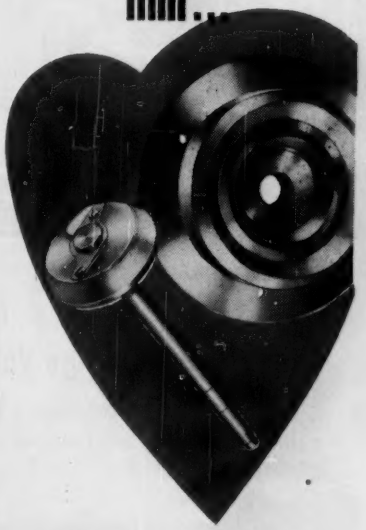
St. Regis Paper Co. has begun a $30-million expansion of its kraft and paperboard mill in Tacoma, Wash. Included in additions are a 350-ton/day paper and paperboard machines, five new pulp digesters, new washing and screening lines, new furnace and boiler facilities, a new lime kiln and new wood-chipping units.



Miles Chemical Co. has just placed on stream a $3.6-million expansion of its citric-acid capacity at its Elkhart, Ind. plant. New capacity enables Miles to now produce 7,500 tons/yr. of anhydrous and hydrated citric acid; shown above are long battery of fermenters. Blown air induces sugar fermentation, thus promotes citric acid formation.

Cargill, Inc. has just placed on stream new soybean-oil and protein-meal processing capacity at South Norfolk, Va. Cargill also recently expanded facilities at Seaford, Del., Wilson, Wash., and Belhaven, N. C. Included in South Nor-

the heart of your mill...



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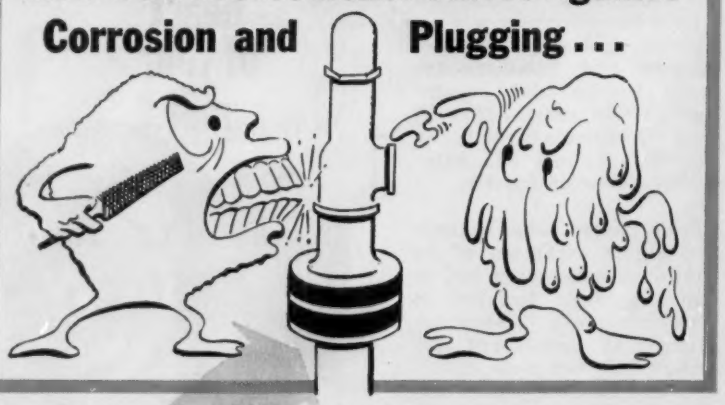
How To Protect Relief Valves Against Corrosion and Plugging...



BS&B *Safety Head* Is A Damage Barrier That Doesn't Change Valve Operating Accuracy

A BS&B Quik-Sert Safety Head mounted to the inlet of a safety or relief valve provides these advantages not otherwise attainable...

- Isolates valve from product contamination.
- No product loss as long as the rupture disc remains intact.
- Process or product may be changed without varying valve design or construction.
- Overpressure relief is instant, reaching the valve through wide open, unrestricted orifice.
- Eliminates shut-down time during normal operation.
- Bottle-tight seal during normal operation assures no loss of product.

The absence of a BS&B Safety Head may mean a change of valve construction when process or product is modified. However, with valve mounted above a BS&B Quik-Sert Safety Head the same valve may be used for varying services without alteration. You save the cost of additional equipment. You save the cost of time-consuming valve changes.

If you have a corrosion and plugging problem with your relief valves, call your nearest BS&B Safety Head sales center now. Or write to...

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OVER 60 YEARS
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ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

folk expansion are new multipurpose extraction, storage and elevator facilities.

A. H. Robins Co., pharmaceutical producer, plans a $1-million expansion of its Richmond, Va., plant. Construction, to begin next spring, is scheduled for completion by early 1961. •

U. S. Industrial Chemicals Co., New York, N. Y., has just formed U. S. I.-International to promote polyethylene sales in Europe; headquarters are located in Zug, Switzerland.

Urethane Corp. of America was recently incorporated to produce and market urethane foams in western U.S., Hawaii, Alaska and British Columbia. Foam production is scheduled to begin this month at the new San Francisco, Calif., plant under license and technical service agreement from Mobay Chemical Co.

Clute Corporation, pneumatic-conveyor manufacturer, has acquired Asbestos Bonding Corp. of Napa, Calif. Clute will employ its air-separation know-how to mill ABC's asbestos deposits at Napa.

Century Chemical Corp., New York, N. Y., continues its move to acquire chemical producers all over the country. Century just added these four to its list of many acquisitions: Chemo Puro Manufacturing Corp.; Oil & Chemical Terminals, Inc.; Asphalt Div. of Oil & Chemicals Products, Inc. and Chemo Puro AG in Europe.

Dayton Rubber Co. of Dayton, Ohio, and N. V. Vereenigde Nederlandsche Rubberfabieken (Hevea) have formed Dayton-Hevea to market auto-

PRODUCTION COSTS DECREASE...

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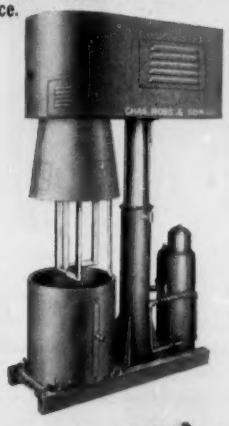
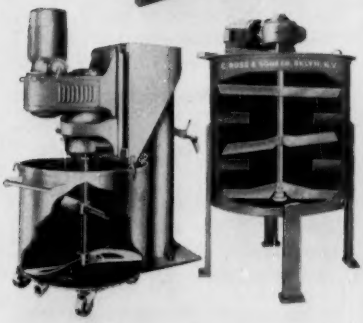
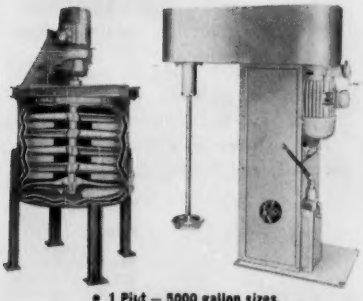
There is only one Mixer that is the most efficient for each different mixing requirement — let us recommend the best Mixer for your use based on our wide variety of types and almost a century of experience.







- 1 Pint — 5000 gallon sizes.
- Standard designs, or with any modifications required.
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CHAS. ROSS & SON CO., INC.

Leading mfgrs. of wet or dry grinding Mills, Kneaders and Mixers of all types — since 1869.

150 CLASSON AVE., BROOKLYN 5, N. Y.

motive and industrial rubber in Europe; headquarters will be located in Arnhem, Netherlands.

General Services Administration has awarded exclusive contract to H. A. Taylor Co., East Orange, N. J., for sale of the 800-acre, Morgantown, W. Va., chemical complex, shown above. Plant cost near $65-million to build, was operated by Du Pont to produce wartime ammonia, methanol, formaldehyde and hexamethylenetetramine.

OVERSEAS BRIEFS

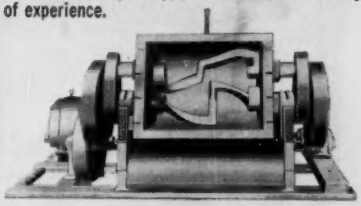
India: Government reveals plans to establish an autonomous corporation, Hindustan Chemicals and Fertilizers, to manage up to 20 fertilizer-chemical complexes now being planned. Among the 20 are giant plants, now being designed or constructed for: Nangal, Trombay (near Bombay), Sindhri and Andhra (*Chem. Eng.*, Oct. 5, pp. 58-62). And Koppers is now negotiating with Indian government for construction of a 100,000-ton/yr., nitrogen plant in Bajasthan in northern India, to be managed by HCF.

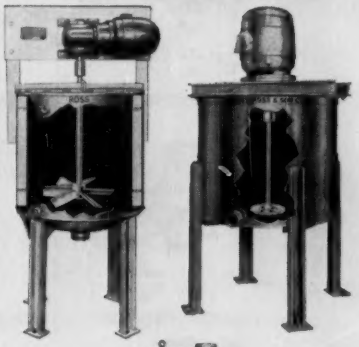
Israel: American-Israel Paper Mills of Hadera, Israel, put into operation this month its $8-million pulp and paper expansion. Agricultural wastes,

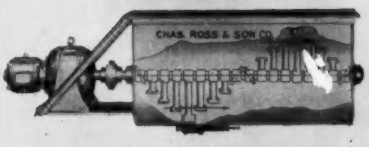
PROFIT MARGINS INCREASE...

WHEN THE BEST MIXER IS USED FOR EACH APPLICATION

There is only one Mixer that is the most efficient for each different mixing requirement — let us recommend the best Mixer for your use based on our wide variety of types and almost a century of experience.







- 1 Pint — 5000 gallon sizes.
- Standard designs, or with any modifications required.
- Also Three Roller Mills, Dry Grinding Mills, and other types of Mixing, Grinding and Dispersing Equipment.

CHAS. ROSS & SON CO., INC.

Leading mfgrs. of wet or dry grinding Mills, Kneaders and Mixers of all types — since 1869.

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Your *FISHER/MAN* offers you

SPEEDY DELIVERY

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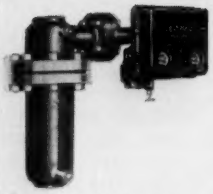
FISHER SUPERMARKET

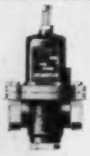
Where you can shop by phone, wire or TWX

Type 657-A with 3500 positioner

Type 4150 and 4160 Wizard II Pressure Controllers



Series 2500-249 and 2500-259B Level-Trols

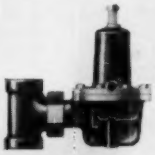


Type 95-H Pressure Reducing Valve

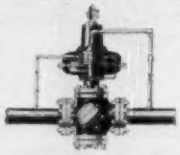
Type 630 "Big Joe" Field Regulator

Series 99 Multi-Purpose Gas Regulators

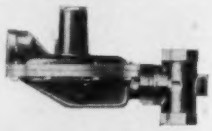
Type 655-A Pressure Regulator



Series 620 and 621 Farm Tap Regulators

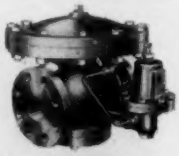


Series 298T Gas Regulators



Series S100 and 730 Service Regulators

Series 67FR Combination Filter-Regulator



Type 92B Pilot Operated Steam Reducing Valve

This "supermarket" availability of Fisher Control Valves and Controllers makes your delivery problems a thing of the past. Fisher keeps a stock of the equipment at left always on hand ready to ship to you at hourly notice. This means emergency requirements are met without costly delivery delays. This stock of control equipment includes all the most popular types in standard sizes.

In addition to the large factory stock, the Fisher offices in the column to the right which are starred carry a big selection of Fisher equipment in inventory to assist you.

Fisher constantly reviews the stock carried in the Supermarket and adds new items from time to time when your needs indicate.

Phone, wire or TWX (Marshalltown 578 or 579) and Fisher will have your order en route in a matter of hours, Saturday and Sunday excepted.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD...CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

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SINCE 1880

Now, for emergency needs contact FISHER or the representatives listed below.

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Barber Engineering & Supply Company
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*CHARLOTTE
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General Meters & Controls Company
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PHOENIX
Cone & Wallace Company
PITTSBURGH
J. G. Chilcoat & Company
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*SHREVEPORT
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Northern Columbia Process Equipment Company
*WICHITA-LIBERAL
Sullivan-Mears Company
WINNIPEG
Mechanical Valve & Engineering Spec.

such as cornstalks and straw, are feed to the $21-million pulp and paper mill.

Yugoslavia: Government has awarded L'Air Liquide, an affiliate of American Air Liquide, a $1.6-million contract to construct a gas-separation plant. Project, financed by Development Loan Fund, Washington, D. C., is scheduled for completion by the end of 1960.

Egypt: United Arab Republic, Ministry of Industry has signed an agreement with Pfizer International for establishment of a pharmaceutical-producing plant in Egypt. Pfizer will produce Terramycin, Tetracyn, Sigmamycin, Terra Cortril and Tyzine for Arab markets.

Egypt: Another giant water-electrolysis plant will soon be built (*Chem. Eng.*, Feb. 23, 1959, p. 68). Badische Anilin und Soda Fabrik, A. G. (BASF) is constructing this world's largest electrolysis plant, to produce 1.2-million cu. ft./hr. of hydrogen for ammonia synthesis. BASF holds prime contract for construction of a 400,000-ton/yr. calcium and ammonium nitrate plant, a part of Egypt's vast industrial development program.

Pakistan: Continental Carbon Co. signed an agreement with Pakistan Petroleum Co. for construction of a 3,000-ton/yr. carbon black plant at Sui, W. Pakistan. New plant, to cost $5-million, will be jointly financed by Continental and Pakistan companies.

NEW LOCATIONS

Procon Incorporated has established a new division in Sydney, Australia, to increase services to South Australian petroleum and chemical in-

Problem:
To reduce the cost of marketing polystyrene pellets

Solution:
SPROUT-WALDRON
PNEUMATIC BULK TRUCK

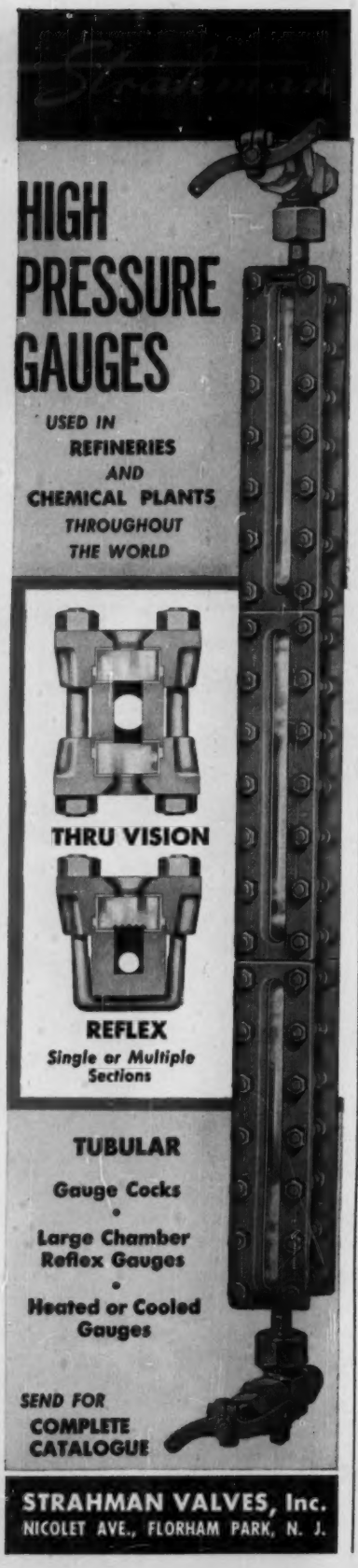
A recent announcement by officials of Cosden Petroleum Corporation tells of a new delivery concept, called, "Curb-Service Marketing." The revolutionary marketing plan involves the delivery of polystyrene pellets by special highway transports.

Key to the new concept is a group of five 28 ft. pneumatic aluminum bulk trailer units designed and built by Sprout-Waldron. Each of these trailers has a capacity of 1182 cu. ft., equivalent to 34,000 pounds of polystyrene pellets. The high powered unloading system permits driver delivery to the customer at the rate of 30 tons per hr. Delivery and storage in bulk cuts down on fringe expenses, such as unloading, warehousing, multiple handling and contamination. Bulk storage also permits instant inventory determination.

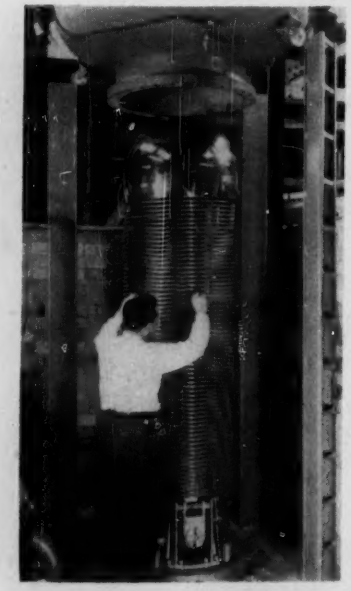
Sprout-Waldron bulk trucks are cutting handling and delivery costs in a variety of chemical applications. For more details, request Bulletin 205-A.

CW/104

SW **SPROUT-WALDRON**
Muncy, Pennsylvania
Size Reduction • Size Classification • Mixing
Bulk Materials Handling • Pelleting



dustry. New firm, named Procon Pty., Ltd., will service five refineries, already built near Sydney, and offer engineering services for plant expansion.



High Voltage Engineering Co. now reaches to the west coast, has established a regional sales and service office at Redwood, Calif. Increased need for high-level, machine radiation sources like the accelerator shown above by west-coast chemical, nuclear and aircraft industries spurred the move.

Crown Zellerbach Corp. has moved to its new headquarters building in San Francisco, has thus consolidated its administrative personnel under one new roof.

Hooker Chemical Corp. announces that it will move its corporate headquarters to New York, N. Y., from Niagara Falls, N. Y. Headquarters of the several Hooker divisions will remain at their present sites.

Phillips Petroleum Co. and **Joanna Western Mills Co.** have formed Phillips-Joanna Co. with headquarters in Chicago, Ill. Newly formed firm will produce and market linear polyethylene film.

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YOUR SELECTION OF PROTECTIVE COATINGS
WRITE FOR YOUR COPY TODAY!
PROVEN IN THE PROCESS INDUSTRIES
• STEEL TANK LINING
• CONCRETE TANK LINING
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FOR IMMERSION SERVICE
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HEAVY BUILD using standard spray or brush methods.
WIDE CHEMICAL RESISTANCE to acids, caustic solvents, salts, de-ionized water, and aqueous solutions.
HIGH TEMPERATURE RESISTANCE not affected by thermal shock.
AIR DRY field applications.
EXCELLENT BOND — No Primers on white metal blasted surface.
OTHER PLASITE PRODUCTS INCLUDE: CAULKING COMPOUNDS
PRIMERS
BAKING COATINGS
WISCONSIN protective coating COMPANY
GREEN BAY, WIS.
REPRESENTED IN PRINCIPAL INDUSTRIAL AREAS
PLASITE

CALENDAR

Society of Plastics Engineers, annual technical conference, Conrad Hilton Hotel.
Jan. 12-15 Chicago, Ill.

Compressed Gas Assn., annual meeting, Waldorf-Astoria Hotel.
Jan. 18-20 **New York, N. Y.**

Engineers Joint Council, annual meeting, Engineering Building.
Jan. 22 New York, N. Y.

Executive Leadership Seminar, Cornell, University-University of Arizona, fee: $600.
Jan. 24-Feb. 5 **Tucson, Ariz.**

Plant Maintenance and Engineering Show, Convention Hall.
Jan. 25-28 Philadelphia, Pa.

American Society for Engineering Education, college-industry conference, Washington University.
Jan. 27-28 St. Louis, Mo.

American Physical Society, annual meeting, Hotel New Yorker.
Jan. 27-30 New York, N. Y.

American Rocket Society, Solids propellants Conference, Princeton University.
Jan. 28-29 Princeton, N. J.

American Institute of Electrical Engineers, national meeting.
Jan. 31-Feb. 5 New York, N. Y.

American Society of Heating & Air Conditioning Engineers, annual conference and Southwest Exposition, Memorial Auditorium—Baker Hotel.
Feb. 1-4 **Dallas, Tex.**

Instrument Society of America, Instrument and Automation Conference and Exhibit, Sam Houston Coliseum.
Feb. 1-5 Houston Tex.

American Society for Testing Materials, committee week, Sherman Hotel.
Feb. 1-5 Chicago, Ill.

Society of the Plastics Industry, Reinforced Plastics Div. meeting, Edgewater Beach Hotel.
Feb. 2-4 Chicago, Ill.

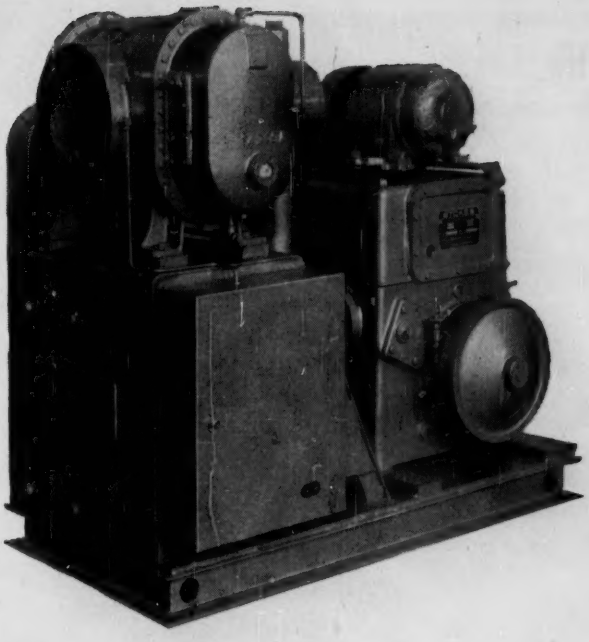
Western Industrial Isotopes Conference, cosponsored by Stanford Research Institute and the University of California, for program contact Conferences Dept., Berkeley campus.
Feb. 3-5 Menlo Park, Calif.

American Society for Metals, metals conference, Fairmount Hotel.
Feb. 4-6 San Francisco, Calif.

Symposium on Gas-Cooled Nuclear Reactors, Franklin Institute-American Nuclear Society.
Feb. 10-11 **Philadelphia, Pa.**

American Institute of Mining, Metallurgical and Petroleum Engineers, annual meeting, Statler McAlpin Hotel.
Feb. 14-18 New York, N. Y.

The Australasian Institute of Mining & Metallurgy, Symposium on Hy-



STOKES **MECHANICAL**

BOOSTER PUMPS

Packaged high-speed pumping systems that feature automatic push-button operation

Stokes Mechanical Booster Pumps are streamlined, compact integrated systems that offer the user greater pumping speed per dollar. The unit consists of a coaxial blower first stage, backed by the latest gas-ballasted Microvac rotary vacuum pump. Four models are available . . . Model 1710, with a 1050-cfm rating—Model 1711, rated at 1160 cfm—the 1712, rated at 2900 cfm—and the 1713, rated at 5100 cfm.

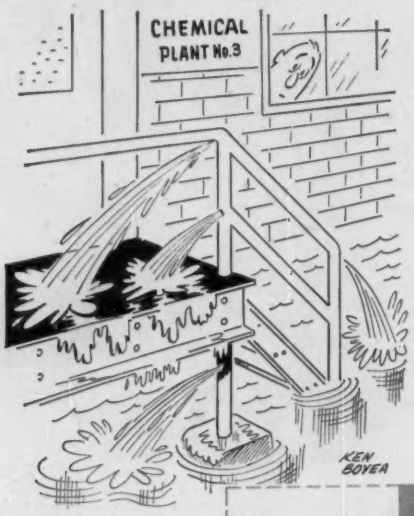
Operation of this Stokes system is entirely automatic. When the pressure has been roughed down to 15 mm Hg, a pressure switch actuates the blower unit. There are no complicated switching or valving procedures necessary. All models feature an ultimate blank-off of 0.5 microns and tremendous throughput.

Call your nearest Stokes office, or contact Stokes' Engineering Advisory Service for complete specifications on all models—or application assistance for your own specific process.

Vacuum Equipment Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

Life in these excited states...



Corrosion is full of surprises

Out-guessing corrosion has been our business for 100 years. We now make 8 types of chemical resistant pipe . . . with valves, pumps, and tanks to match . . . and pretty well know what to expect with them. If anything, our advice is on the *safe* side. Please consult us with *any* problem.

All-purpose rigid PVC. Sched. 40, 80 & 120, ½ to 4". Threaded or socket-weld fittings. Valves ½ to 2". NSF-approved. *Bul. CE-56.*

Improved design . . . now 12 gpm. All wetted parts acid-resistant, wear-resistant Ace hard rubber. Finest available. *Bul. CE-55.*

Flexible poly pipe, ideal for water lines, drains, underground pipe or conduit. Sizes ½ to 2", long coils, NSF-approved for drinking water. *Bul. CE-57.*

World's best chemical valves . . . at moderate prices. All-plastic, rubber-lined, or all-hard-rubber. ⅛" pet cocks to 24" gate valves.

ACE processing equipment of rubber and plastics

AMERICAN HARD RUBBER COMPANY
DIVISION OF AMERACE CORPORATION
Ace Road • Butler, New Jersey

CALENDAR . . .

drometallurgy, S. Australian Dept. of Mines.
Feb. 16-19 Thebarton, Australia

National Society of Professional Engineers, winter meeting, Broadview Hotel.
Feb. 18-20 Wichita, Kan.

American Institute of Chemical Engineers, national meeting, Biltmore Hotel.
Feb. 21-24 Atlanta, Ga.

Technical Assn. of the Pulp and Paper Industry, annual meeting, Commodore Hotel.
Feb. 22-25 New York, N. Y.

Natural Gas Engineering Conference, Oklahoma State University.
Feb. 23-25 Stillwater, Okla.

Pittsburgh Conference on Analytical Chemistry and Spectroscopy, Penn-Sheraton Hotel.
Feb. 29-Mar. 4 Pittsburgh, Pa.

American Society of Mechanical Engineers, Gas Turbine Power conference and exhibit, Rice Hotel.
Mar. 6-9 Houston, Tex.

American Society of Mechanical Engineers, Hydraulic Conference, Rice Hotel.
Mar. 6-9 Houston, Tex.

Instrument Society of America, Temperature Symposium, Deshler-Hilton Hotel.
Mar. 9-11 Columbus, Ohio

The Fiber Society, spring meeting, Roosevelt Hotel.
Mar. 10-11 New Orleans, La.

American Concrete Institute, annual convention, Commodore Hotel.
Mar. 14-17 New York, N. Y.

National Assn. of Corrosion Engineers, 16th annual meeting, Memorial Auditorium.
Mar. 14-18 Dallas, Tex.

Institute of Radio Engineers, national convention, Waldorf Astoria Hotel & New York Coliseum.
Mar. 21-24 New York, N. Y.

Oil Trades Assn. of New York, meeting, Waldorf Astoria.
Mar. 23 New York, N. Y.

New England Gas Assn., annual meeting, Statler-Hilton Hotel.
Mar. 24-25 New York, N. Y.

Textile Research Institute, annual meeting, Hotel Commodore.
Mar. 24-25 New York, N. Y.

American Oil Chemists Society, meeting, Baker Hotel.
April 3-6 Dallas, Tex.

Nuclear Congress, sponsored by Engineer's Joint Council and Engineering and Scientific societies, New York Coliseum.
April 3-8 New York, N. Y.

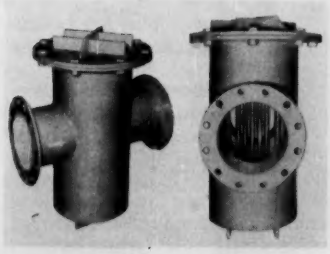
Instrument Society of America, National Chemical and Petroleum Symposium.
April 5-7 Rochester, N. Y.

American Society of Mechanical Engineers-Institute of Radio Engineers-American Institute of Electrical Engineers, third annual conference on Automatic Techniques, Cleveland-Sheraton Hotel.
April 18-19 Cleveland, Ohio

(*Continued from p. 70*)

ylene, the Flame Ionization Detector operates in conjunction with a gas chromatograph. In principle, electronic circuits measure the variations in current between a pair of electrodes as the gas leaving the column burns.

And in Zurich, Switzerland, engineers are talking about a new dust precipitator of extremely small size. In operation, dust-laden feed gas flows turbulently through an assembly of plates at relatively high speed; the dust receives a charge via rubbing contact with the plates' surfaces. After the now-charged dust-laden stream leaves the charging plates, it slows to about 10 ft./sec. (by expansion) and passes through collecting plates charged at high voltage. Charged dust immediately precipitates from the stream. Covering British patent, No. 820,415, is in the name of Davidson & Co.



Magnetic Bowl Traps

For liquid or slurry process piping systems.

To meet process-industry needs for pipeline traps of larger diameter, more compact design and lower cost, Eriez has introduced a line of permanent magnetic bowl traps in seven standard sizes. Able to withstand pressures to 75 psi. and temperatures to 650 F., the traps vary in size from 6 to 18 in. by 2-in. increments.

Nonelectric magnetic tubes forming the core of the trap efficiently arrest and retain large or small pieces of tramp iron, effectively guarding filters, pumps and other process equip-

Versatile Carrier Conveyors Replace Men and Machines!

Versatile Carrier Natural-Frequency Conveyors are "doubling" as processing units in many chemical plants, *replacing costly labor and process steps.*

The conveying and processing of chemical products, in all shapes and sizes, are Carrier specialties. One, and often more, high cost process unit can be eliminated in most chemical plants by merely installing *one dual-purpose Carrier vibrating conveyor.*

Some of the jobs where these low-cost, multi-purpose conveyors are meeting rigid process requirements include: washing, dewatering, sizing, screening, coating, cooling, flattening bags and distributing to multiple outlets.

All Carrier vibrating equipment features rugged, sanitary construction plus the exclusive, patented Natural-Frequency drive to assure gentle conveying and to prevent product damage or degradation.

For further information write: Carrier Conveyor Corporation, 216-A North Jackson Street, Louisville 2, Kentucky.

CARRIER
NATURAL-FREQUENCY VIBRATING EQUIPMENT
Engineering Specialists in Vibrating Equipment

CONVEY ● FEED
DEWATER ● SCREEN
COOL ● AGGLOMERATE
DRY ● SCALP ● COAT
DISTRIBUTE ● ELEVATE
● FLATTEN BAGS

American 200 Series Chemical Feed Pumps

• METERING ACCURACY OF ±1%

• CAPACITY TO 1624 GPH.

New 200 Series Simplex model can pump up to 812 gph. Duplex model has double this capacity. Maximum pressure of 10,000 psi.

Easy, inexpensive operation is assured by these quality features:

- Self-contained lubrication system—no downtime for lubrication.
- E-Z Clean Cartridge Valves simplify maintenance.
- Interchangeable liquid ends for greatest adaptability in the field.
- Precision screw adjustment on crank for easy accurate stroke regulation.
- Sealed Self-aligning bearings on crank and crosshead withstand greater radial and axial thrust loads.
- Crossheads of hardened and ground steel ride on cast iron.
- Heavy duty reducers.
- NEMA frame motors.

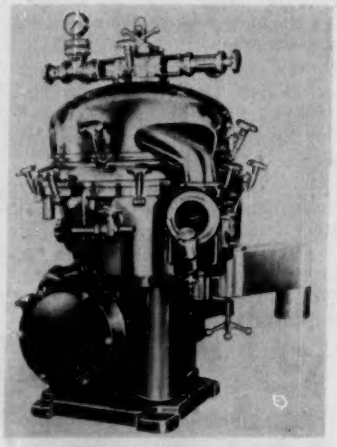
Precision built 200 Series pumps handle a wide variety of "tough," corrosive materials. In Chemical Processing, Refining and Boiler Feed operations, the pumps assure highest accuracy in feeding precisely metered fluids in virtually all ratios, with flow, temperature, pressure, conductivity, PH and other controlled process variables.

Write today for more information.

AMERICAN METER COMPANY
INCORPORATED (ESTABLISHED 1836)
pump division
13500 PHILMONT AVE. PHILADELPHIA 16, PA.

ment from damage and excessive maintenance. Trap use also insures against intrusion of ferrous contaminants into finished product.

Standard model has a welded-pipe body and reinforced plate construction. However, if required, the unit can be supplied with a resin coating, or an all-stainless steel construction for resistance to corrosion.—**Eriez Mfg. Co., Erie, Pa.** **165A**



Centrifugal Separators

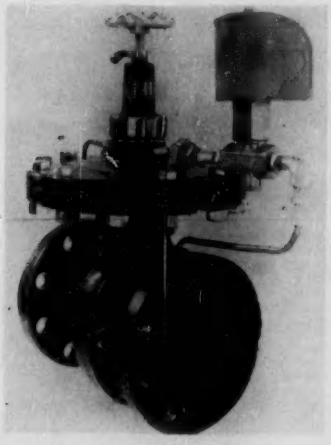
For purification, concentration, clarification.

Primary applications for the Model PX Self-Opening Separator line are in operations where the amount of slurry solids would quickly fill the bowl of standard separators, where there is insufficient feed to use nozzle bowl separators, or where high concentration of solids discharge is necessary.

In operation, PX machines allow solids to build up along the bowl wall. When separated solids reach a predetermined quantity, a series of apertures on the bowl wall becomes exposed, and solids eject while the bowl is operating at full speed. Solids discharge takes only a few seconds, and totally eliminates manual bowl cleaning.

Three models are available: PX 207 with a capacity range of 200-1,500 gph.; PX 309 with 400-3,000 gph. capacity; and PX 213 of 1,000-6,000 gph. capacity.

Specific capacity depends upon feed type and solids content.—**The De Laval Separator Co., Poughkeepsie, N. Y.** 166A



Solenoid Regulator

Electric signal controls steam input to pilot.

Among the features of a new line of solenoid-actuated regulators for on-off control are packless construction, silent operation, and positive shut-off. When the solenoid opens, steam enters a pilot chamber and operates the main valve as a normal pressure regulator.

Size range for ductile iron construction is ¼ to 3 in.; for bronze 1¼ to 2 in.; and cast iron, 2½ to 3 in. Maximum temperature is 500 F.; pressures to 250 psi.—**OPW-Jordan, Cincinnati, Ohio.** 167A

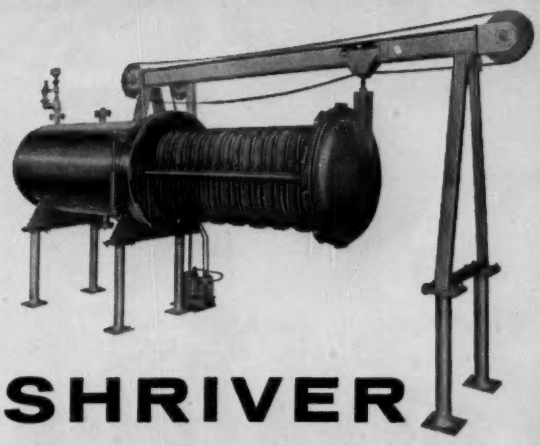
Repair Kit

Patches leaky piping, repairs broken equipment.

Developed for on-the-spot repairs of process equipment, the Carbo Fix repair kit contains epoxy resin, catalyst, glass-fiber cloth, measuring spoons, stirring paddle and instruction booklet. When properly prepared, the epoxy material cures to a hard, tough, tightly-bonded patch that repairs breaks, leaks, cracks and wear.

Two types are available.

Engineered to improve processing



SHRIVER

Vertical Leaf Pressure Filter offers outstanding operating efficiency

- *For large volume clarification*
- *For high filtration efficiency*
- *For quick discharge of solids and easy cleaning*

The Shriver "HTVL" horizontal tank vertical leaf pressure filter provides the maximum in performance. It incorporates the most advanced design features to assure perfect clarity of filtrate; uniform, reasonably dry cake; easy accessibility for cleaning and compactness.

The filter is available in 27 standard combinations of tank size and number of filter leaves. Leaf assembly, filtrate discharge and leaf carriage simplify operation.

There's a Shriver "HTVL" filter unit for your needs—now or projected.

Send for handy Bulletin 146 which tells all you'll want to know about the filter for better filtration.

Filter presses

Horizontal tank, vertical leaf filters

Vertical tank, vertical leaf filters

Vertical tank, horizontal plate filters

Plastics polymerizers and slabbers

Continuous thickeners

Filter media textile and metal

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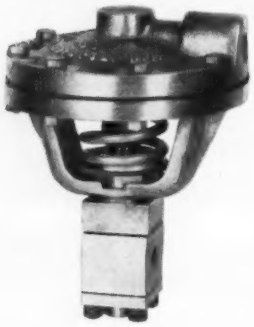
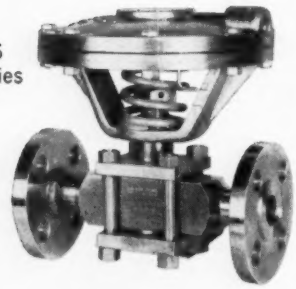
MINIATURE VALVES



501 Series

526 Series



RUGGED

"BANTAM"

THROTTLING CONTROL VALVES

Compact throttling controls of the 501 series have one-piece barstock bodies with screwed ends and are available with linear, equal percentage or quick-opening plug characteristics. This series offers six operators, direct and reverse acting, including two with positioners.

The 526 series includes 6 body styles in globe, angle and 3-way design — with screwed or flanged ends. Four bonnet types cover standard, high or low temperature and packless applications. Six control operators are offered with up to 50 square-inch diaphragms.

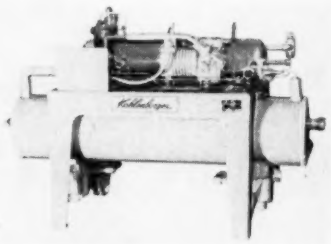
	501	526
Pressure Rating	1000 psi (at 450°F)	1000 psi (at 450°F)
Temperature Rating	−70°F to +450°F	−70°F to +450°F (750°F with finned bonnet)
Maximum Cv.	0.63	10.0 (1" connections)
Lift	⅛"	7/16"
Seat Area	0.038 sq. in.	up to 0.601 sq. in.
Connections	⅛", ¼", ½" N.P.T. Standard (others available)	¼" to 1" N.P.T. ½" to 1" flanged

Send for the BANTAM Catalog No. B-1 and other technical data on Dahl pneumatic and hydraulic valves.

George W. Dahl Company, Inc.
86 Tupelo Street
Bristol, Rhode Island

NEW EQUIPMENT . . .

Carbo Fix S is a general repair material with good chemical resistance for repairs to most surfaces, including brass. Carbo Fix C has excellent chemical resistances, and is recommended where chemical attack is of major consideration. — **Carboline Co., St. Louis, Mo.** 167B



Air Dryer

Sub-dewpoint refrigeration knocks down H_2O, oil.

According to the manufacturer, the new KCD Air Dryer condenses water and oil vapors from compressed process or instrument air, thus permitting use of standard compressors instead of special carbon-ring machines. The dryers also eliminate the need for special desiccant drying beds, reversing valves and associated auxiliary equipment.

Components include a semihermetic motor compressor (F-12 refrigerant cooled), automatic return-oil trap on the compressor discharge line, shell-and-coil condenser receiver, 150-psi. refrigerant-cooled exchanger, and appropriate regulating and safety controls. — **Kohlenberger Engineering Corp., Fullerton, Calif.** 168A

Pt-Clad Stainless Steel

Composite material made via solid-phase bonding.

Sheet, wire and tubing made of an alloy of platinum (0.5% rhodium) clad to Carpenter 20 stainless steel are claimed to be stronger and less expensive than materials commonly used in corrosive atmospheres. Depending on thickness of the platinum

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You save all kinds of time and money when you insulate "hard-to-get-to" pipe with G-B Snap*On, the one piece pipe insulation molded of fine glass fibers. It's easy to carry 3-ft. G-B Snap*On sections to the job—even if you have to crawl or climb there . . . and they snap on pipe in one easy motion. No worry about breakage, for rough treatment won't harm G-B Snap*On. It's safer, too, because workmen can concentrate on their footing—and forget about dropping the insulation!

Add to these advantages the unequalled ease and economy of applying G-B Snap*On on straight runs, its superior thermal efficiency and permanence —and you can readily understand why G-B Snap*On is industry's No. 1 choice for heated or cold lines. It's available plain or with a variety of jackets, in sizes from copper tubing to 36″, so there's a size and type just *made* for your next job!

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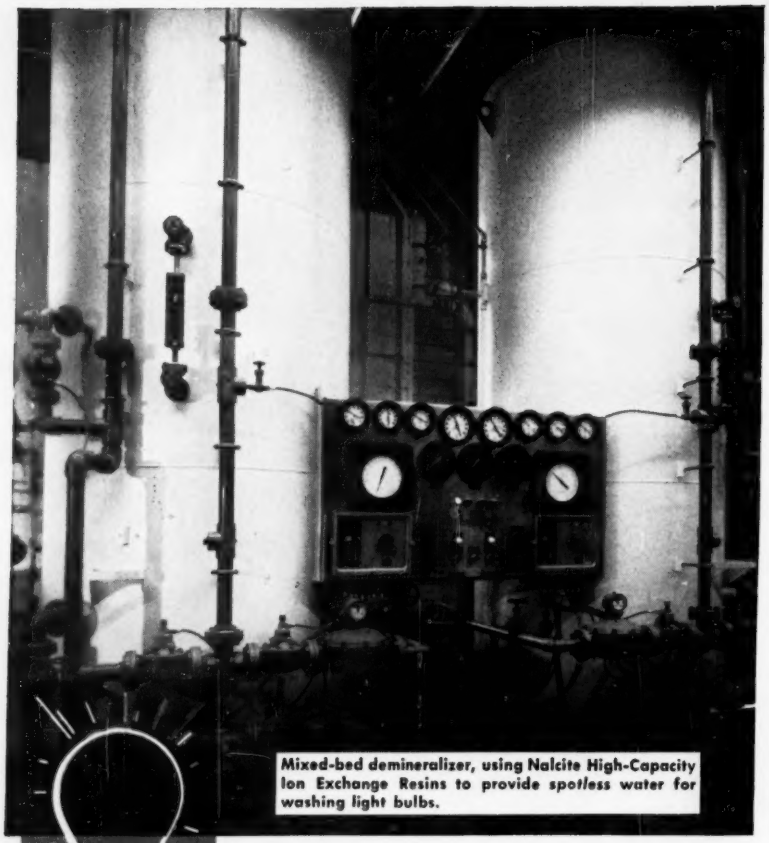

Mixed-bed demineralizer, using Nalcite High-Capacity Ion Exchange Resins to provide *spotless* water for washing light bulbs.

BRIGHT IDEA!

for spotless light bulbs

Nalcite® **DEMINERALIZED WATER**

Highest quality demineralized water is needed to wash light bulbs to sparkling spotlessness for this major manufacturer . . . Nalcite Cation and Anion Exchange Resins, working in a modern mixed-bed demineralizer, do the job here — as they can do it on any water that needs upgrading for most efficient use.

Whether you want to wash a light bulb or get better boiler feed water, Nalcite Exchangers have capacity, stability and other performance advantages you should know about.

NEW WATER CONDITIONING HANDBOOK

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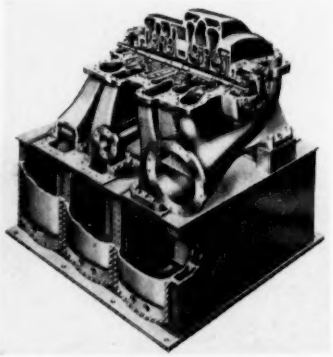
layer, service temperatures can vary to 1,000 F.

Clad steel strips come in thicknesses from $\frac{1}{16}$ to 0.005 in., and widths to 12 in. Platinum thickness ranges from 0.001 to 0.005 in. Cladding on the tubing can be either on the inside wall, outside or both. Wire is offered with platinum cores or platinum cladding. Bonding process for all forms uses no brazing alloy or other intermediate material. **—Metals & Controls Div., Texas Instruments, Inc., Attleboro, Mass. 168B**



Centrifugal Compressor

Features integral intercoolers between stages.

A new centrifugal air compressor, featuring integral intercoolers between each compression stage for high efficiency, is available in capacities from 5,000 to 38,000 cfm. Output pressure is 110 psi. Each model comes as a complete package, including matching driver, intercoolers and lubricating system.

Single-case construction plus base mounting of the intercoolers cuts floor space requirements as much as 40% over machines of comparable horsepower (1,000 to 8,000 bhp.). Side connections permit up or down piping, and eliminate space-consuming axial inlets. The horizontally split case enables easy access to rotor and other parts for inspection or maintenance. Stock prime mover can be either an induction motor or a synchronous motor.—**Clark Bros. Co., Olean, N. Y. 170A**

BRIEFS

Lightweight filters for oil, fuel, or pneumatic systems are available with capacities of ½, 3, 6 and 12 gpm. Present ratings are for nominal 10-micron filtration or for nominal 5-micron work. Since the fabrication process requires no welding, dissimilar metals can be used in filter design.—**Purolator Products, Inc., Rahway, N. J.** 171A

Base-metal thermocouple wire known as Thermo-Kanthal offers significantly longer life and improved stability over commonly used thermocouple materials because of its greatly increased resistance to oxidation. Stability of operation is particularly impressive in the 1,800 to 2,300 F. range.—**The Kanthal Corp., Stamford, Conn.** 171B

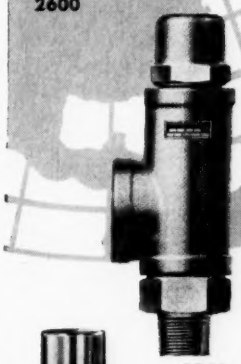
Explosion-proof union for use with rigid conduit and fittings in hazardous areas is available in the ½-in. size. Authorized for Class 1, Groups A, B, C and D; and for Class 2, Groups E, F and G.—**Appleton Electric Co., Chicago, Ill.** 171C

Equipment Cost Indexes . . .

	June 1959	Sept. 1959
Industry		
Avg. of all.....	234.3	235.8
Process Industries		
Cement mfg.	227.9	229.9
Chemical	235.7	237.5
Clay products	221.5	223.4
Glass mfg.	222.5	224.2
Paint mfg.	226.6	228.0
Paper mfg.	227.1	228.8
Petroleum ind.	231.4	232.9
Rubber ind.	234.0	235.7
Process ind. avg...	232.8	234.1
Related Industries		
Elec. power equip...	246.7	239.4
Mining, milling	237.1	239.0
Refrigerating	264.7	266.4
Steam power	221.8	223.2

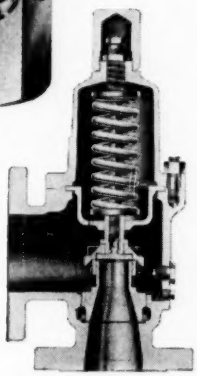
Compiled quarterly by Marshall and Stevens, Inc., of Chicago, Ill., for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124—6 for method of obtaining index numbers; Feb. 23, 1959, pp. 149-50 for annual averages since 1913.

2600



2740

2745



2950

in process safety-relief valves

From the Near East to our own Far West . . . the name Farris on safety-relief valves has been a standard synonym for safety since 1943. The patented design features on all Farris full-nozzle valves combine to offer the ideal concept of a trouble-free, 100% safe safety-relief valve for every application.

SERIES 2600

The most popular top-guided, self-aligning, safety-relief valve for process piping service. Maximum pressure, 150 to 2500 psig, RF/RJ. Plain or Lever types. Standard or BalanSeal bellows construction.

SERIES 2740

A cast-steel relief valve of simplified design for use where extreme blow down accuracy is not essential, but where durability, compactness are. Pressures to 3500 psig at 450°F; 2000 psig at 800°F. Sizes ½" to 2".

SERIES 2745

An extremely rugged, compact, high pressure bar stock nozzle valve. Internal parts stainless steel. Adjustable blow down; flat seat; self-aligning stem and disc. Pressure to 10,000 psig. Sizes ½", ¾", 1".

SERIES 2950

A cast iron safety-relief valve including most of the exclusive Farris features found in the Series 2600. Max. pressure, 250 psig at 450°F, 400 psig at 150°F. Plain cap, open lever or packed lever types.

Complete information is provided in Catalog FE-118, covering both selection and sizing of Farris process Safety-Relief Valves. Send for your copy today.

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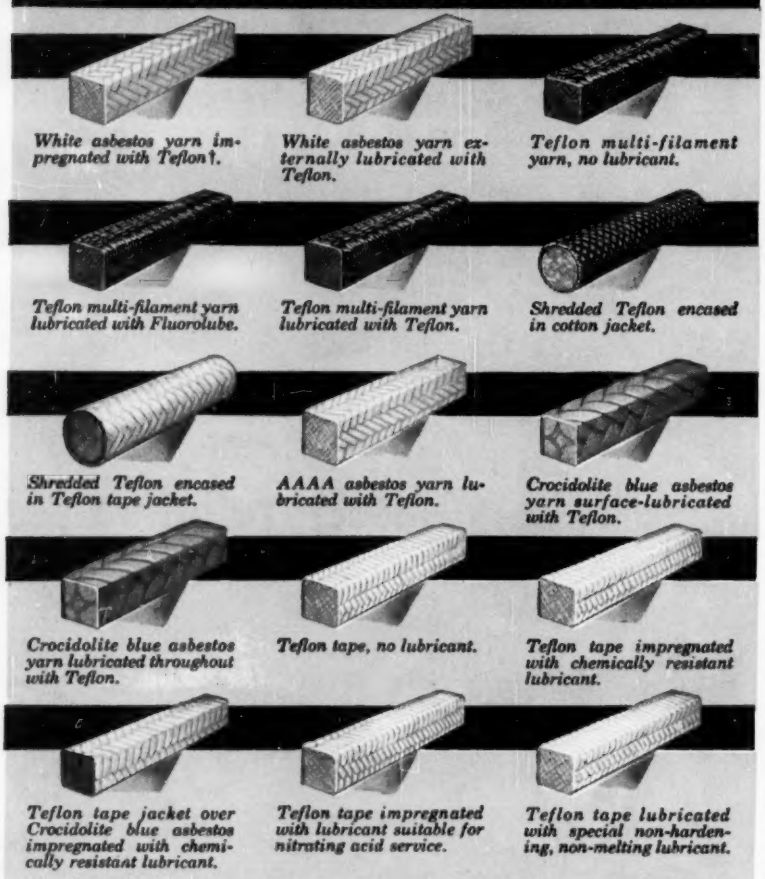
15 SPECIFIC PACKINGS FOR ALL CORROSIVE SERVICES


White asbestos yarn impregnated with Teflon†.
White asbestos yarn externally lubricated with Teflon.
Teflon multi-filament yarn, no lubricant.
Teflon multi-filament yarn lubricated with Fluorolube.
Teflon multi-filament yarn lubricated with Teflon.
Shredded Teflon encased in cotton jacket.
Shredded Teflon encased in Teflon tape jacket.
AAAA asbestos yarn lubricated with Teflon.
Crocidolite blue asbestos yarn surface-lubricated with Teflon.
Crocidolite blue asbestos yarn lubricated throughout with Teflon.
Teflon tape, no lubricant.
Teflon tape impregnated with chemically resistant lubricant.
Teflon tape jacket over Crocidolite blue asbestos impregnated with chemically resistant lubricant.
Teflon tape impregnated with lubricant suitable for nitrating acid service.
Teflon tape lubricated with special non-hardening, non-melting lubricant.

John Crane CHEMLON *BRAIDED PACKINGS

Specific service conditions are always best handled with a packing designed for the purpose. This is especially true when it comes to the hard-to-handle liquids in the chemical, petrochemical and refinery industries.

For this reason John Crane has developed 15 individual field-proved types of Chemlon Braided Packings. Within this line there is a type and style that will meet any combination of service conditions and requirements.

1. All known industrial acids, alkalis or solvents.
2. Temperatures from −120°F to +600°F.
3. High or low shaft speeds, also valve stems.
4. Longer packing life due to lower coefficient of friction and non-raveling construction.

Send in your service condition and we will recommend a Chemlon Braided Packing best suited to your application. Request Bulletin P-325.

Crane Packing Co., 6451 Oakton St., Morton Grove, Ill. (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

†T. M. for DuPont Teflon

*T. M. for the Best in DuPont Teflon

CRANE PACKING COMPANY

TECHNICAL

Necessary Reading

GAS CHROMATOGRAPHY, 2nd. Ed. By A. I. M. Keulmans; edited by C. G. Verver. Reinhold Publishing Corp., New York. 231 pages. $7.50.

PRINCIPLES AND PRACTICE OF GAS CHROMATOGRAPHY. Edited by Robert L. Pecsok. John Wiley & Sons, Inc., New York. 226 pages. $6.75.

Reviewed by Horace P. Warrington, Jr., Sterling-Winthrop Research Institute, Rensselaer, New York.

Gas chromatography is rapidly becoming important to the production engineer as a tool for in-stream analysis of liquids or gases. Although these two books are primarily written for the analytical chemist, they are necessary reading for understanding the theory and scope of this field.

Each of these two books thoroughly covers the theories concerning the many parameters found in gas chromatography including such recent developments as the use of capillary columns and flame ionization detectors. Theoretical discussions are presented in a very easy-to-understand manner in Dr. Pecsok's book. Each chapter has been written by a man experienced in the field of gas chromatographic analysis in a manner indicating that the book is intended for use as a text in a basic course in gas chromatography.

A distinctive feature of Dr. Keulemans' book is the descriptive information of equipment used in gas chromatography with full coverage of detectors (from titration types to the recently developed ionization types), columns (a very useful list of column materials is listed in the appendix), and sample introduction methods. Of special interest in Dr. Keulemans' book is the use of gas-solid chromatography for testing catalyst activity and the combining of a reactor directly

BOOKSHELF

J. B. BACON

to gas-chromatographic equipment for studying catalytic processes.

Each book describes how gas chromatography is not limited to analysis, but can be used to determine some properites of liquids such as heat of solution.

BRIEFLY NOTED

SOVIET RESEARCH IN ANALYTICAL CHEMISTRY OF URANIUM 1955-1957. *Consultants Bureau, Inc., 227 W. 17th Street, New York 11, N. Y.* $10. Contains nine papers that appeared in Soviet Journal of Analytical Chemistry and one paper from Geochemistry Section of Proceedings of Academy of Sciences of USSR.

SOVIET RESEARCH IN FLUORINE CHEMISTRY 1949-1956. *Consultants Bureau, Inc., 227 W. 17th Street, New York 11, N. Y.* $45 *complete set.* Divided into three volumes. Vol. I ($15) deals with organic fluorides and fluorocarbon olefins; Vol. II ($20) deals with inorganic fluorides and analysis; Vol. III ($20) deals with hydrogen fluoride, boron trifluoride and its etherates, and fluoroborates.

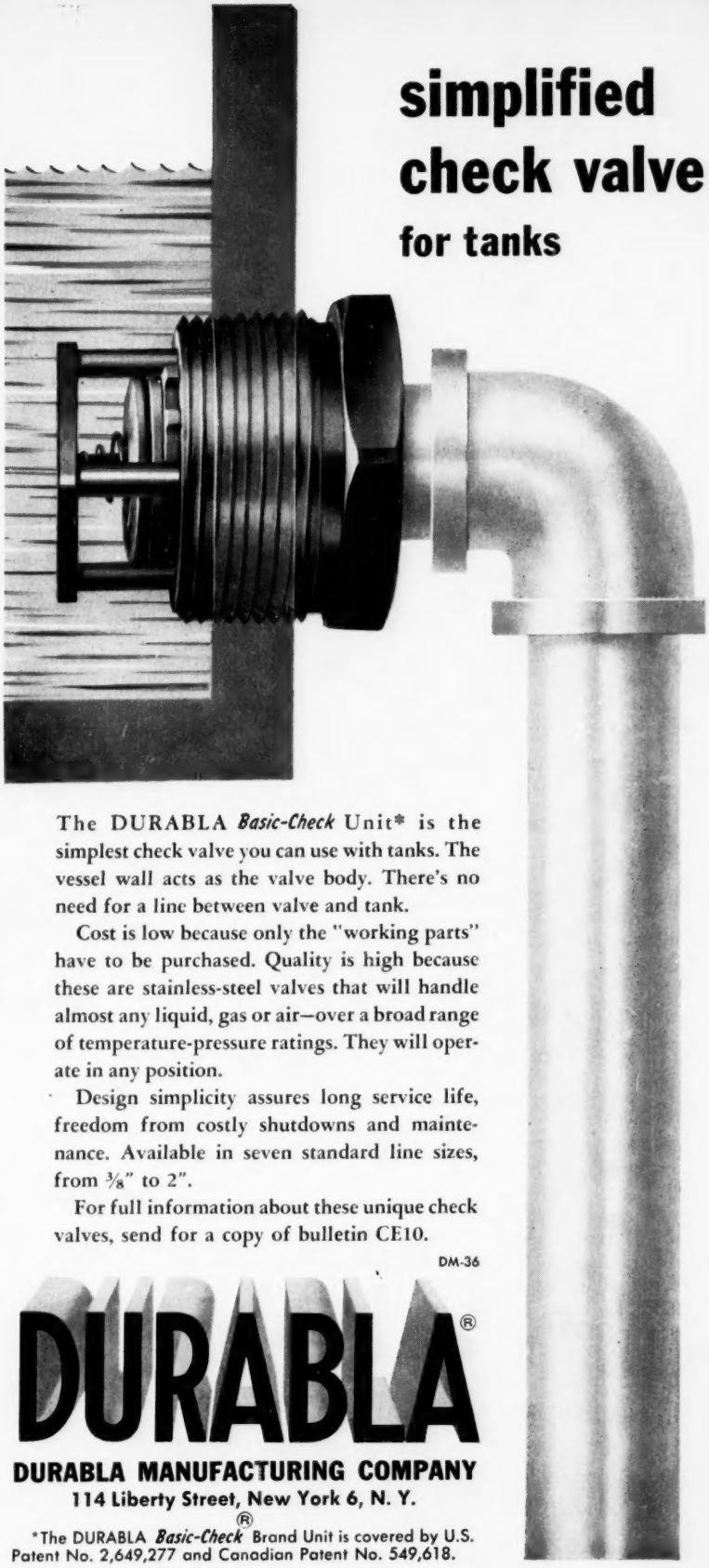
SELECTED DATA ON URANIUM ALLOYS. 76 *pp. Compiled by Helen C. Friedemann and Henry H. Hausner. Sylvania-Corning Nuclear Corp., Bayside, Long Island, N. Y.* $1. Includes bibliography of 470 references, binary phase diagrams of 27 alloys and about a dozen tables and graphs showing behavior of some uranium alloys under conditions of corrosion and irradiation; from widely scattered sources.

MORE NEW BOOKS

INTRODUCTION TO RUBBER TECHNOLOGY. Edited by Maurice Morton. Reinhold. $10.

CELLULOSE PULP AND ALLIED PRODUCTS. By Julius Grant. Interscience. $8.50.

DIGITAL AND SAMPLED-DATA CONTROL SYSTEMS. By Julius T. Tou. McGraw-Hill. $15.



simplified check valve for tanks

The DURABLA *Basic-Check* Unit* is the simplest check valve you can use with tanks. The vessel wall acts as the valve body. There's no need for a line between valve and tank.

Cost is low because only the "working parts" have to be purchased. Quality is high because these are stainless-steel valves that will handle almost any liquid, gas or air—over a broad range of temperature-pressure ratings. They will operate in any position.

Design simplicity assures long service life, freedom from costly shutdowns and maintenance. Available in seven standard line sizes, from ⅜" to 2".

For full information about these unique check valves, send for a copy of bulletin CE10.

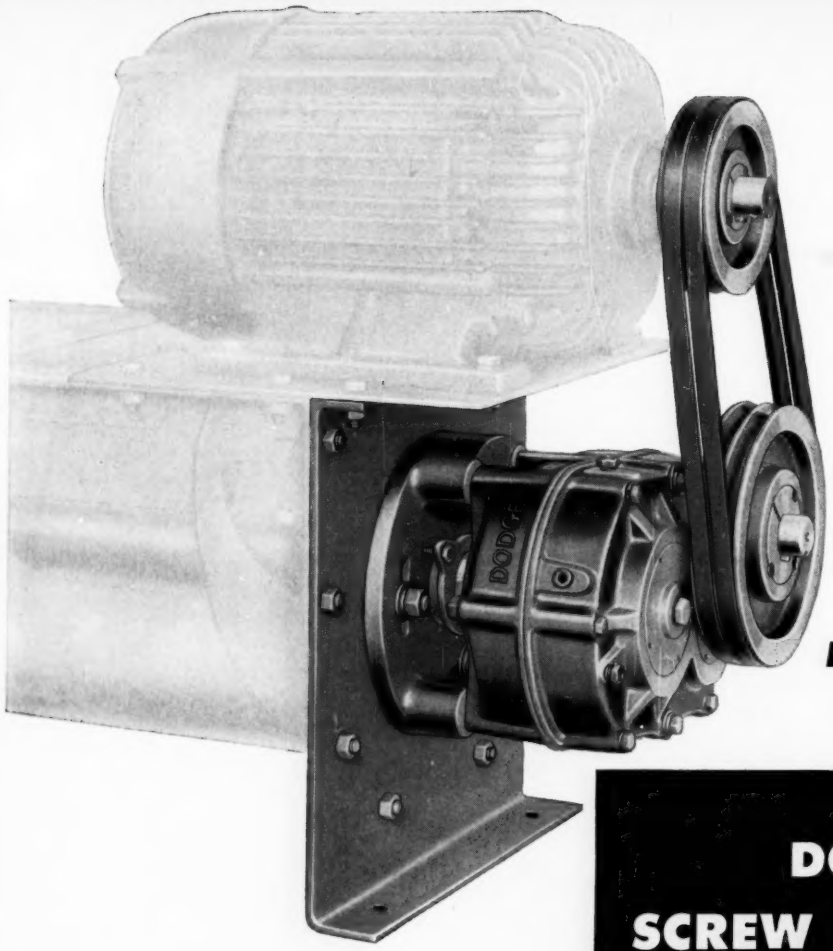
DM-36

DURABLA®

DURABLA MANUFACTURING COMPANY

114 Liberty Street, New York 6, N. Y.

*The DURABLA *Basic-Check* Brand Unit is covered by U.S. Patent No. 2,649,277 and Canadian Patent No. 549,618.



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Entirely Different!

DODGE SCREW CONVEYOR DRIVE

A complete package drive, including

- **Rugged, high-efficiency Reducer.**
- **Quick-removable Driving Shaft.**
- **External Packing Gland.**
- **Trough End (optional).**

Amazing new ease of installation—new ease of maintenance—new economy! No external thrust bearing or motor base is necessary. (However, a motor base of special design is available as optional equipment.) Pre-selected Taper-Lock V-Belt drives give required speeds. Built-in puller makes it easy to change driving shaft—without opening reducer. External packing gland protects reducer. Helical steel gears. Timken Bearing equipped throughout. Available from stock with 1½", 2", 2 7/16", 3" and 3 7/16" driving shafts. Ask your Dodge Distributor, or write us for bulletin giving complete technical data.

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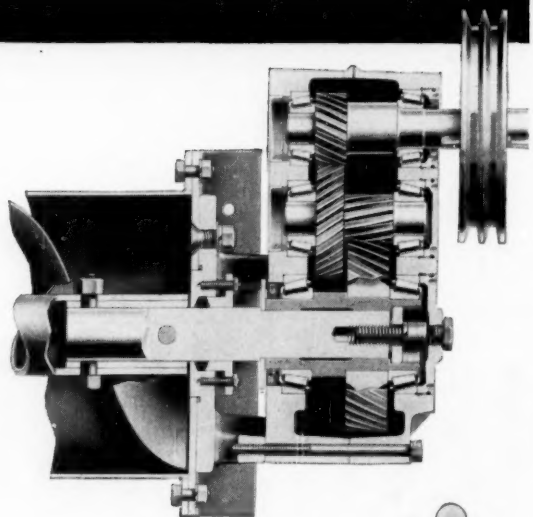

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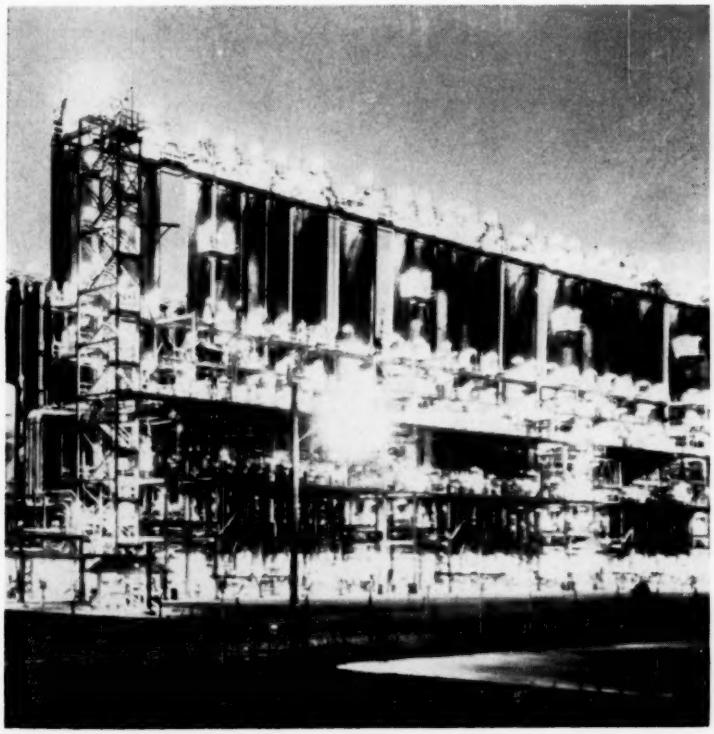
LETTERS: PRO & CON

C. H. CHILTON



Heavy Water Rectified

Sir:

Your Process Flowsheet, "Secrets of Low-Cost Heavy Water" (Oct. 19, pp. 170-173), contains errors of fact and interpretation that I believe you will wish to bring to the attention of your readers.

Your discussion of the relative investments at Dana and Savannah River is misleading; it implies that the difference between the costs of the two plants was due entirely to the difference in staging. Actually, the lower cost of the Dana plant was due in some measure to use of an existing plant site and existing process and service facilities. The more extensive use of stainless steel for heat-exchanger tubes, tower trays and valves at Savannah River also contributed to its higher first cost; lack of these stainless components at Dana was corrected later at the expense of operating cost.

The significant difference in investment that can be attributed to difference in staging is that associated with the larger total volume of towers at Savannah River. This is offset somewhat by more simple piping and controls and the obviation of spare pumps and blowers. We believe that the net increased investment for the two-stage units is just about balanced by their greater productivity.

Only two-thirds of the towers at Savannah River are stainless lined. Corrosion of the carbon steel towers has been slight, and with benefit of this knowledge gained from seven years' operating experience, stainless steel lining would not be used in any future plant.

Inhibitors are not used. Amines were tried in pilot-plant operation and were deleterious rather than beneficial.

One of the major problems faced in operation of the H_2S-

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The Flexible Cushion Coupling

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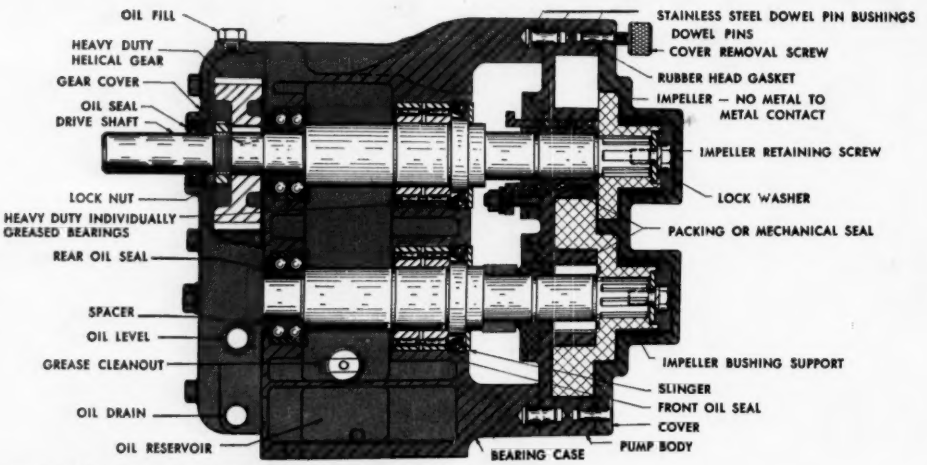

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SLOW SPEED
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Helical Timing Gears
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Mechanical Seals
— single and dual mechanical seals (John Crane) . . . interchangeable packing glands or mechanical seal construction.

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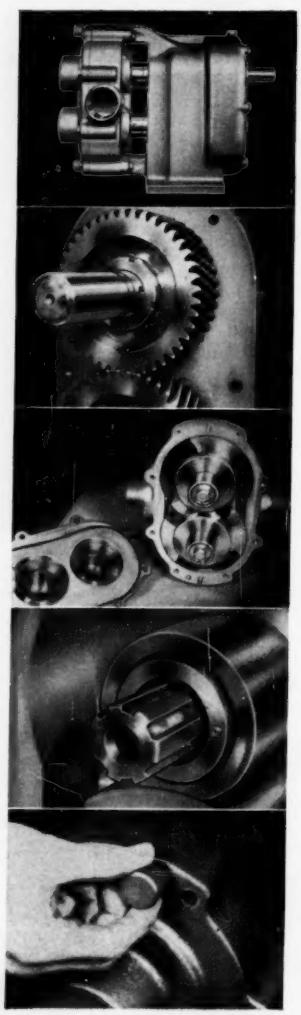
— all 100% Stainless Steel in contact with the product stream.

Quick Disassembly
— pump cover releases with simple turn of the thumb screw (no tools).



To handle problem liquids of high or low viscosity.

This pump merits your attention. 5 years in the development stage . . . 2 years of rigorous, in-field testing . . . engineered to meet the diverse demands of the liquid-processing field. Examine these features:

- **twin-balanced impellers**
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- **interchangeable packing gland or mechanical seal construction**
- **self priming**
- **shaft supported by three heavy-duty bearings to eliminate deflection**
- **iron pipe or flange-type connections**
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A new "Waukesha" designed and engineered to deliver less turbulence, pulsation, aeration and agitation on products of high or low viscosity . . . a smoother operation which assures longer life, less maintenance. This, combined with its slow speed, heavy duty design and, for its size, greater production volume than any other pump, makes it a revolutionary advancement in the industrial pump field. Field engineering service . . . sales representatives in all major cities. Write for Bulletin P-302.

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WAUKESHA FOUNDRY COMPANY
Dept. 43, Waukesha, Wisconsin

World's largest producer of sanitary stainless steel positive displacement rotary pumps and leading producer of corrosion-resistant castings.

exchange process was, and is, control. Your statement that the process has proved relatively insensitive to "normal flow variations" is correct only if it is made clear that in the operation of these plants such variations are less than ±0.5%. Success of the process has depended very largely upon development of methods to detect and interpret changes of flow of this magnitude and to hold flows steady within these limits.

Your article also contains discrepancies in the values of equipment sizes, operating conditions and unit quantities.

A complete and up-to-date description of the AEC heavy water plants and their operation may be found in the article, "Production of Heavy Water," by W. P. Bebbington and V. R. Thayer, *Chem. Eng. Prog.*, Sept. 1959, pp. 70-78. All aspects of this technology are covered in DP-400, "Production of Heavy Water—Savannah River and Dana Plants—Technical Manual." This is an AEC report and is now available for purchase from the Office of Technical Services.

W. P. BEBBINGTON
E. I. du Pont de Nemours & Co.
Aiken, S. C.

Pro: Reverse Thinking

Sir:

I would like to offer a few comments on Donald Q. Kern's interesting article on "Speculative Process Design" (Oct. 5, 1959, pp. 127-142).

Any industrial research organization worthy of existence will not go beyond the laboratory stage without some evaluation of the economics of the process to be studied. This evaluation usually includes an estimate of capital investment based on a conceptual design of the industrial system. Thus any development program in real life automatically uses Kern's idea of "reverse thinking." This is the first step in any experimental approach to pilot-plant design, followed by evaluation of the areas of knowledge and ignorance.

Whether any experimental work is required depends entirely on the concept of similar-

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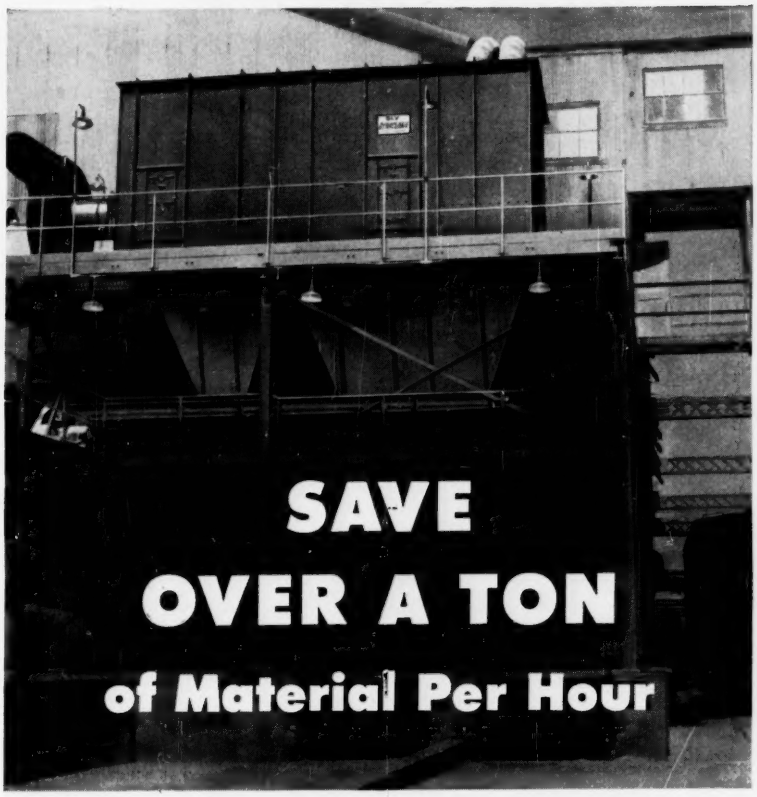
at American Potash



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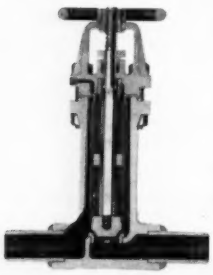

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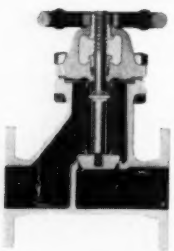

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Robertshaw

MR. CONTROLS

PRO & CON . . .

ity. In fact, Kern's entire "speculative approach" leans heavily on this concept. In every one of his examples, he assumes similarity to some system by using some empirically determined relationship or some simplifying assumption. This is an excellent approach and should be used where possible.

The problem of interpolation and extrapolation is well stated by Kern. However, his example of a large plant designed for a very wide operating range developed from a pilot plant with a very narrow operating range is not a realistic one. It is usually the opposite situation—a wide range of variables examined experimentally and a narrow, but optimum, range of variables designed into the commercial unit. In addition, we must know the effects of nonstandard situations during startup, shutdown and malfunction of controls to avoid hazards in operation.

E. L. CLARK
Chemical Engineer
Pittsburgh, Pa.

JUST BETWEEN US...

Dear Readers:

We invite you to join with us in celebrating a birthday. Our Process Flowsheet department is now "of age." Over the past 21 years this original (but now much copied) feature has brought you 280 flowsheet articles, covering products from acetic acid to zinc oxide and zirconium.

To celebrate this event we have compiled an index of these flowsheets by product (300 of them), process used, plant and location. You can obtain a free copy of this index by writing to Editor, *Chemical Engineering*, 330 W. 42nd St., New York 36, N. Y.

We were prompted to start reminiscing about this department recently when we received a letter from a reader who commented: "In my opinion, the flowsheets you publish have been one of the great contributions to

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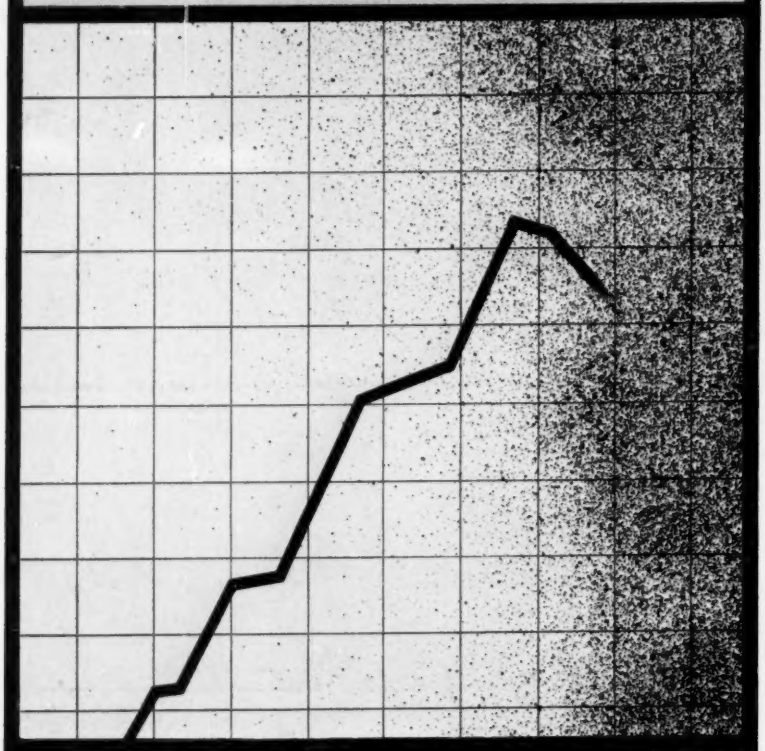

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the chemical engineering profession."

These kind words set us to work appraising and evaluating in a rough way just what this department has accomplished since January 1939. For one thing, Process Flowsheet has scored a number of "firsts"—giving you the first look inside many new plants. A few examples over the years are butyl and buna-S rubber in 1943, penicillin in 1944 and reserpine tranquilizer in 1957. This year we proudly count such "firsts" as Linde's molecular sieves and Merck's Diuril.

More important than these "firsts" is the continuing publication of articles which show you the latest in applied chemical engineering technology — whether the product is a glamorous new synthetic or an old standby like caustic soda.

R. A. LABINE
Assistant Editor
Chemical Engineering

CE's History

Chemical Engineering, with which is incorporated *Chemical & Metallurgical Engineering*, is the successor to *Metallurgical & Chemical Engineering*, which in turn was a consolidation of *Electrochemical & Metallurgical Industry* and *Iron & Steel Magazine*.

The magazine was originally founded as *Electrochemical Industry*, in September 1902, and was published monthly under the editorial direction of Dr. E. F. Roeber. It continued under that title until January 1905 when it was changed to *Electrochemical & Metallurgical Industry*. In July 1906 the consolidation was made with *Iron & Steel Magazine* which had been founded eight years previously by Dr. Albert Sauveur. In January 1910 the title was changed to *Metallurgical & Chemical Engineering*, and semi-monthly publication was begun Sept. 1, 1915. On July 1, 1918, the title was changed to *Chemical & Metallurgical Engineering* and weekly publication was begun Oct. 1, 1919. Monthly publication was resumed in March 1925.

In August 1946 the words *"& Metallurgical"* were dropped from the main title to bring its name more in keeping with the editorial content. Biweekly publication began in January 1958.

Dr. E. F. Roeber was editor of the paper from the time it was founded until his death Oct. 17, 1917. After a brief interim he was succeeded by H. C. Parmelee. Ten years later, Nov. 1, 1928, Sidney D. Kirkpatrick was appointed editor.

On May 1, 1950, Dr. Kirkpatrick was named editorial director, a post he filled until his recent retirement, and John R. Callaham succeeded him as editor. September 1 of last year Mr. Callaham assumed the duties of a vice president of the McGraw-Hill Publishing Company. He was succeeded as editor in chief by Cecil H. Chilton.

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Use either of these two postcards for catalogs . . . for more information on equipment . . . on materials . . . on advertised items . . . for helpful reprints of editorial articles. Be sure to fill out the other side of cards. *Important—For pages showing more than one advertised item, use this guide to numbers on cards above.*

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75-78b—Storage tanks
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75-78d—Pipe & fittings
75-78e—Reactors
75-78f—Columns
75-78g—Conical rotary dryer-blenders

129a—Hydroxylamines
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129d—Hydroxylammonium acid sulfate
153a—Processing kettles
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167b—Filter presses
167c—Horizontal tank, vertical leaf filters
167d—Vertical tank, vertical leaf filters
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167h—Filter media textile & metal
167i—Diaphragm pumps

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SW Pointers

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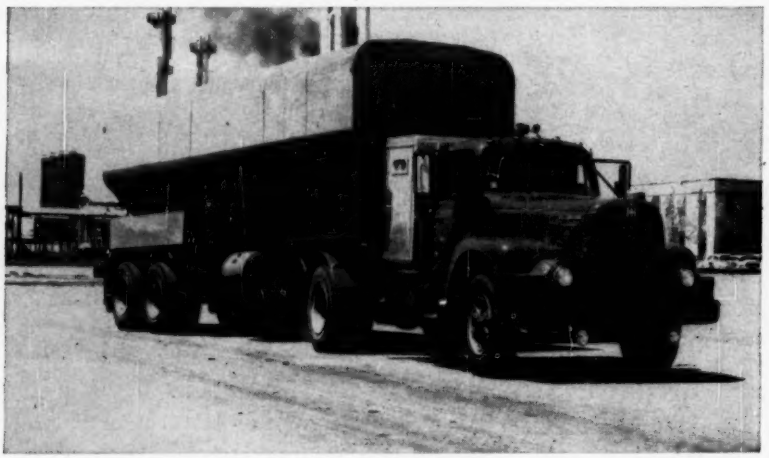
Published in the interest of better processing by Sprout, Waldron & Co., Inc., Muncy, Pa.



One of five Sprout-Waldron Pneumatic Aluminum Bulk Trucks for handling polystyrene pellets in Cosden Petroleum's new "curb service marketing" delivery concept. Note Cosden's modern 32,000 barrel custom refinery in background.

SPROUT-WALDRON BULK TRUCK HANDLES POLYSTYRENE PELLETS

A recent announcement by officials at Cosden Petroleum Corporation, Big Spring, Texas of a new delivery concept, "curb service marketing" is arousing considerable interest throughout the plastic industries. The revolutionary marketing plan involves a delivery of polystrene pellets by special highway transports direct from the purchasing plant to the customer.

The key to the new concept is a group of five 28' pneumatic aluminum bulk trailer units designed and built by Sprout-Waldron. Each of these trailers has a capacity of 1,182 cubic feet which is equivalent to 34,000 lbs. of polystyrene pellets. The high powered unloading system permits delivery to the customer at the rate of 30 tons per hour. Delivery and storage in bulk cuts down on fringe expenses such as unloading, warehousing, multiple handling and contamination. Bulk storage also permits instant inventory determination. Storage bins can be located at the most suitable point in the plant since the pneumatic unloading system built into the trucks permits delivery anywhere a pipe can be run.

Recent completion of the new polystyrene plant is said to make Cosden Petroleum the first producer able to integrate all phases in the manufacture of this basic material. Both general purpose crystal polystyrene and high impact polystyrene are being produced. The styrene monomer used in manufacturing polystyrene is produced in an adjacent plant also owned and operated by Cosden.

For more information on how Sprout-Waldron pneumatic bulk trucks may fit your application, write for Bulletin 205.

COP/102

READER SERVICE . . .

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Chemicals

Acrylic Emulsions.....54 p. book gives results of 6-yr. study of applications and exposure tests of exterior paints made with 100% acrylic resin emulsion, Rhoplex AC-33.
186A Rohm & Haas Co.

Activated Carbons.....A complete line for every purpose; design & prefabricate complete purification, separation & recovery systems to meet your needs. Bul. J-101.
R188 *Barnebey Cheney

Alkanolamides.....Booklet describes properties and uses of alkanolamides and glycol esters. Includes formulas for shampoos, household cleaners, dishwashing compounds.
186B Clintwood Chemical Co.

Amines.....Bulletin describes new low cost, nonvolatile aliphatic amine mixture, Amine 248, for use in resins for adhesives, curing agent in epoxies.
186C Du Pont Co.

Ammonium Bicarbonate.....A study of its properties & a test sample will reveal new or different facets of Ammonium Bicarbonate to you. Available on request.
61 *Allied Chem., Solvay Div.

Antioxidants.....26 p. catalog describes a line of food-grade antioxidants an dtheir use in fat and oil-containing foods. Summarizes Federal regulations governing use.
186D Eastman Chemical Products Inc.

Anti-statics.....4 p. describes products numbered 79 & 79-OL for use in thermoplastics, thermosets, polyethylenes and other synthetic fibers & styrene plastics.
186E Merix Chemical Co.

Carbon Black.....6 p. folder reviews the first commercial production of carbon black-styrene butadiene rubber masterbatches, outlines typical applications.
186F United Carbon Co.

*From advertisement, this issue

LITERATURE

E. M. FLYNN

Cationic Salts.....22 p. booklet covers nine chemicals and new formulations used for conditioning fertilizers & hygroscopic salts. Flow diagrams depict application.
187A Armour Industrial Chemical

Chemical.....1, 3-Butylene Glycol can help you make better polyesters, polyurethanes, surfactants, humectants, plasticizers, & coupling agents. Information.
55 *Celanese Chemical Co.

Chemicals.....New folder, "Chemicals for '60," offers 11 different chemicals in development quantities and 12 commercial. Fields include nitrogen heterocyclics.
187B Ansul Chemical Co.

Chemicals.....8 p. booklet contains comprehensive, alphabetical listing of company's products. Some are commercial, others can be when demand warrants.
187C Reilly Tar & Chemical Corp.

Chemicals.....The 1959 Physical Properties of Synthetic Organic Chemicals . . . a comprehensive description of the properties & applications of 400 chemicals.
137b *Union Carbide Chem. Co.

Chlorinating Agents.....A new 24-page bulletin contains a wealth of information on choosing the right chemical for a given chlorination step. Tech. Bul. 328-B.
79 *Hooker Chemical Corp.

Cryogenic Fluids.....Folding pocket card presents in tabular form the physical property equivalents of some cryogenic fluids. Includes critical temperatures, pressures.
187D Linde Co.

Etchant.....3 p. bulletin describes an etching solution for making fluorocarbon polymers bondable to other materials. Describes procedure, safety precautions.
187E Acton Laboratories

Fluorescent Penetrant.....New spray-on Zyglo finds all cracks, pores, leaks in nonmagnetic materials. Illustrated bulletin includes low prices of Zyglo materials.
BL203 *Magnaflux Corp.

*From advertisement, this issue

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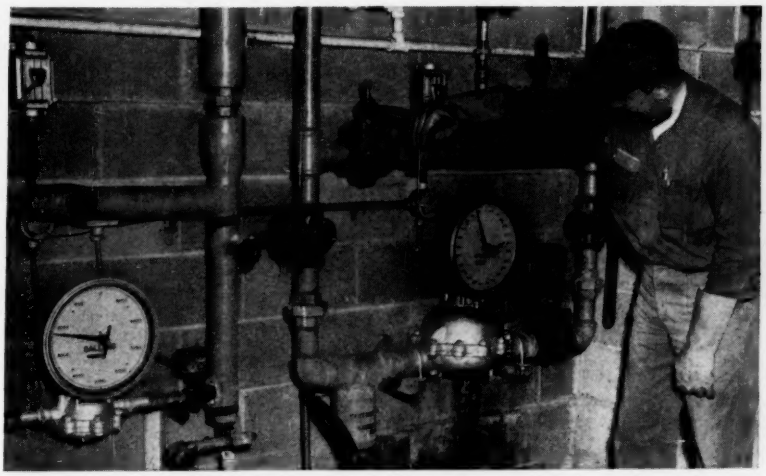
Complete Batch Uniformity

When Liquids are measured with Niagara Electricontact Meters



Niagara Electricontact Meters being used to simultaneously meter sodium hydroxide (right) and water (left) in a large eastern chemical plant.

The gallonage you set is what you get . . . EXACTLY!

Whatever your process — if you measure, meter, control or add liquids, you can be sure of absolute batch or process uniformity with Niagara Electricontact Meters.

Exacting accuracy is assured by positive displacement Niagara metering. When the required volume has passed through the meter, the flow is automatically stopped by a solenoid valve activated by the meter itself. There is no possibility of human error. Dirty sight glasses offer no problem.

Time and labor are saved. The central control station shown above permits the operator to accurately measure the dilution of caustic soda to precise process requirements without leaving his station. Since he never has contact with the caustic, the entire process is carried out in a safer fashion. Obsolete methods of dipping, rodding are a thing of the past with Niagara Meters.

Why not let us show you how Niagara Meters can improve your process? Mail the coupon today for a free catalog.

BUFFALO METER COMPANY
INCORPORATED
2891 Main Street • Buffalo, New York

BUFFALO METER COMPANY, Inc.
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☐ Please send me additional information on Niagara Meters.
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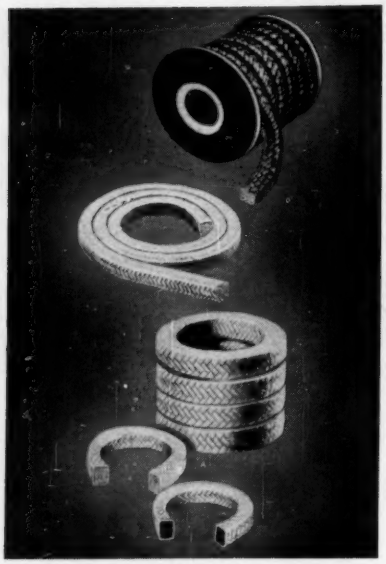
CHEMPRO SQUARE-BRAIDED TEFLON* PACKINGS



Chempro Square-Braided Teflon Packings are tough, strong and chemically inert. They outlast ordinary braided packing many times over, holding together longer against even the strongest acid, alkali or organic solvent. Here are four popular Chempro Square-Braided Teflon packings:

STYLE No. 400 PACKING
Constructed of pure Chempro tape, braided square without lubrication. For highly corrosive services where a lubricant is undesirable.

STYLE No. 400-F PACKING
Resilient, square-braided packing of Chempro Teflon multi-filament yarn, without lubrication. For pump and valve applications in highly corrosive services where the packing must "give" to a certain extent.

STYLE No. 400-FI PACKING
Square-braided packing of Chempro Teflon multi-filament yarn and impregnated with Teflon suspensoid. This dense packing was developed for gas and vapor services where other lubricated packings were not acceptable.

STYLE No. 400-FL PACKING
Made by square braiding Chempro Teflon multi-filament yarn and externally lubricating with a non-hardening and non-melting lubricant. Recommended for high speed applications and highly corrosive services, from freezing to 350° F.

These Chempro Braided Teflon packings are available in all sizes in standard 1/16" increments from 1/8" to 3/4" square—in spool or coil forms. Can be cut to specific ring sizes, if desired.

Write for revised Bulletin CP-552.

*duPont trademark

CHEMICAL & POWER PRODUCTS, Inc.

5 Broadway, New York 4, N.Y.

LITERATURE . . .

Germicide.....2 p. data sheet describes use of a 75% concentrate of n-alkyl isoquinolinium bromides as a germicide-fungicide. Lists fungi against which it works.
188A Onyx Oil & Chemical Co.

Guar Gum.....16 p. booklet contains up to date data on viscosity vs. shear rate, electrolyte compatibility, properties as a settling, filtering & flotation agent.
188B Stein Hall & Co.

Halofluorocarbon.....Kel-F Halofluorocarbon products for corrosion control & contamination prevention are fully illustrated & described in a new brochure.
188C Minnesota Mining & Mfg. Co.

Hydrogen.....New 36-page book contains complete information about hydrogen and its production. Dependable design, engineering & construction of hydrogen plants.
47 *Girdler Construction Corp.

Inert Fluids.....Complete data on the remarkable properties of 3M Inert Fluids in terms of your product design, miniaturization or performance problems.
16 *Minnesota Mining & Mfg. Co.

Ion Exchangers.....Sixty pages of concentrated data and useful tables on water conditioning with Nalcite Ion Exchangers is offered. Bulletin Z-5.
170 *Nalco Chemical Co.

Nitrogen Tetroxide.....can be used in the wood pulping, rubber, metal recovery & lubricant purification industries. A 59-pg. bulletin gives information & appplication data.
149 *Allied Chemical, Nitrogen Div.

Organic Chemicals.....28 p. physical properties booklet describes more than 400 synthetic organic chemicals. Contains information on use, properties, shipping.
188D Union Carbide Chemicals Co.

Plasticizers.....32 p. catalog describes a complete line of plasticizers. Covers physical and chemical properties and complete specification data, selectivity tables.
188E Eastman Chemical Products

Polyethylene.....Latest developments in cast polyethylene film are described in a 12 p. booklet. Compares cast, quenched and blown films. Describes casting equipment.
188F U. S. Industrial Chemicals Co.

Primary Amyl Alcohol.....is available in tank cars or trucks, & in 55-gal. drums (carload or LCL lots). Additional information in Technical Bulletin F-8517C.
137a *Union Carbide Chem. Co.

Protective Coatings.....4 p. coating chart compares coating systems for concrete floors regarding their resistance to chemicals, thermal shock, impact, skidding.
188G Carboline Co.

Pyridines.....20 p. booklet describes the properties and uses of pyridines and piperazines. Covers physical properties, constant-boiling mixtures, solubilities.
188H Union Carbide Chemicals Co.

Sodium Compounds.....available in a variety of grades & strengths suited to every need. Each offers high quality & uniformity. Specific information on request.
41 *Allied Chem., General Chem.

* From advertisement, this issue

how to keep a guppy happy

Your pet fish—or your friends downstream will breathe easier and longer if activated charcoal keeps the water pure. Reducing stream pollution can often pay its way in profitable recovery of waste products, in better public relations. Well worth looking into.

how to smell no evil

Some people wear gas masks (containing activated charcoal). Others breathe air freshened with activated charcoal air purifiers. They (the people) work better, more safely. You save money by recirculating warmed or cooled air instead of blowing it away. Suggest you ask your plant or consulting engineers about it.

activated carbon

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Barnebey Cheney

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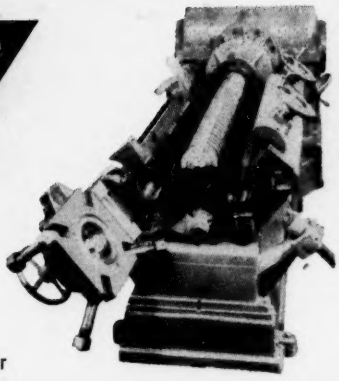
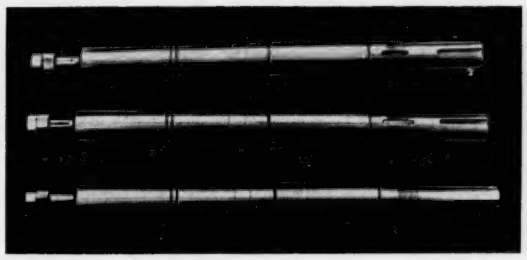


Shaft for chemical mixer

ARMCO STEELS / for chemical processing equipment



Centrifugal pump shafts

Homogenizer studs

Colloid mill wear ring

Armco 17-4 PH Stainless Steel Gives You New Solutions to Old Problems

Economical precipitation-hardening stainless steel combines advantages of martensitic and austenitic stainless steels, cuts equipment maintenance

Parts shown here are typical of many applications in chemical processing equipment where Armco 17-4 PH Stainless Steel has solved old and troublesome material problems.

This special precipitation-hardening stainless steel combines high strength and hardness at temperatures to about 600 F with excellent resistance to corrosion and the ability to withstand galling and abrasion. Added advantages—low coefficient of thermal expansion, distortion-free low temperature heat treatment and resistance to stress-corrosion — increase its utility.

In food processing, petrochemical, atomic energy, sugar refining, and petroleum refinery equipment, Armco 17-4 PH has replaced more expensive alloys as well as standard stainless grades because its unique combination of properties improves performance and cuts maintenance costs.

Consider how and where Armco 17-4 PH Stainless Steel may be used to solve metal problems in the equipment *you* make or use. Write Armco Steel Corporation, 1030 Curtis Street, Middletown, Ohio, for complete information.

ARMCO STEEL

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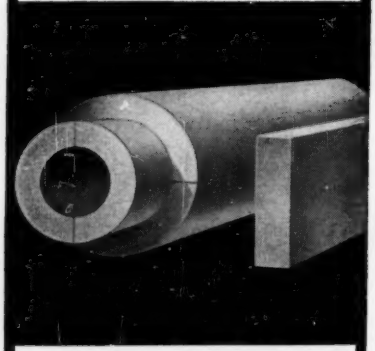

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For complete details, see Chemical Engineering Catalog or Sweet's Catalog.

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PIONEERS IN CALCIUM SILICATE INSULATION

LITERATURE . . .

Sulfur.....Manual arranged in loose leaf style initially consists of 4 sections & appendix covering origin, deposits, reserves, properties, handling, storage, use.
190A Texas Gulf Sulphur Co.

Sulphur.....Manual covers all phases of handling, storage & use of Sulphur, both Solid & molten, plus useful information on sampling, analyzing & broad properties.
31 *Texas Gulf Sulphur Co.

Textile Chemicals.....44 p. booklet describes more than 100 chemicals used in 41 textile processing operations. Included are adhesives, after-treating agents for dyeing.
190B Union Carbide Chemicals Co.

Construction Materials

Aluminum Coating.....New brochure on hot-dip aluminum coating to prevent atmospheric corrosion and high-temperature oxidation of ferrous parts is available.
190C Arthur Tickle Engineering

Aluminum Conduit.....is easy to cut, bend & thread, corrosion resistant, non-sparking, color coded, nonmagnetic & is approved by Underwriter's Laboratories, Inc. Facts.
10-11 *Aluminum Co., Rome Cable Div.

Brass Tube.....Catalog describes complete line of brass tube and pipe fittings. Detailed product illustrations and specifications. Available on request.
190D Brabant Brass Mfg. Co.

Castings.....alloyed to fit each specific requirement & finished to any extent desired. Melt, castings & finishing are carefully controlled. Bul. 3150-G.
208 *The Duraloy Company

Coatings.....“D-A” will withstand temp. up to 600 F. Other Coatings are available in a complete range of types for any condition & temp. up to 2200 F. Catalog No. MPC.
TL205 *The Markal Company

Elastomer.....Hypalon is resistant to corrosive chemicals, abrasion, ozone, sunlight, weather, etc. Additional information & subscription to the “Elastomer Notebook.”
123 *E. I. du Pont de Nemours

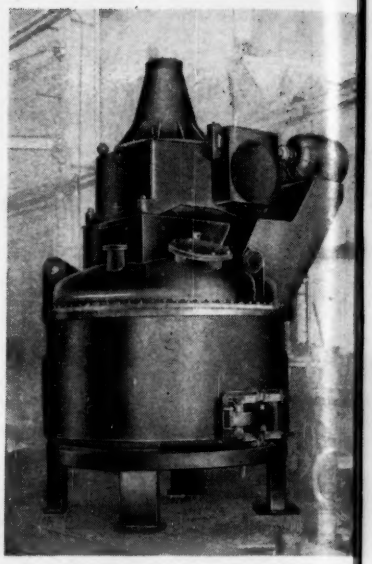
Fused Quartz.....Complete, illustrated catalog on Vitreosil pure fused quartz industrial ware is now available. Many standard shapes & sizes.
R205 *Thermal American Fused Quartz

Insulation.....Snap-On is the one piece pipe insulation molded of fine glass fibers. Available plain or with a variety of jackets in sizes from copper tubing to 36″.
169 *Gustin-Bacon Mfg. Co.

Insulation.....Calsilite is available in various thicknesses of pipe coverings & blocks and is insoluble in water. Can withstand normal acids & alkalis.
L190 *The Ruberoid Co.

Irons.....Eight Ni-Resist irons to choose from. Answer all your corrosion problems. All the details in “Engineering Properties and Applications of Ni-Resist.”
181 *International Nickel Co.

* From advertisement, this issue



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Engineered and researched by our staff of

ENGINEERS

Pan Dryer cast in our

FOUNDRY

Weldment cover fabricated in our

PLATE SHOP

Machined in our

MACHINE SHOP

Tested by our

X-RAY EQUIPMENT

See 8-page catalog in C. E. C. for complete facilities of Process Equipment Division of

BETHLEHEM FOUNDRY & MACHINE CO.

BETHLEHEM, PENNA.

It's the Nash!

The ability of Nash Compressors to maintain original performance over long periods is no accident. Nash Compressors have but a single moving element, the Nash Rotor. This rotor is precision balanced for long bearing life, and it revolves in the pump casing without metallic contact. Internal lubrication, frequent cause of gas contamination, is not employed in a Nash. Yet, these simple pumps maintain 75 lbs. pressure in a single stage, and afford capacities to 6 million cu. ft. per day in a single compact structure.

Nash Compressors have no valves, gears, pistons, sliding vanes or other enemies of long life. Compression is secured by an entirely different principle of operation, which offers important advantages often the answer to gas handling problems difficult with ordinary equipment.

Nash Compressors are compact and save space. They run without vibration, and compression is without pulsation. Because there are no internal wearing parts, maintenance is low. Service is assured by a nation-wide network of Engineering Service offices. Write for bulletins now.

No internal wearing parts.

No valves, pistons, or vanes.

No internal lubrication.

Low maintenance cost.

Saves floor space.

Desired delivery temperature Automatically maintained.

Slugs of liquid entering pump will do no harm.

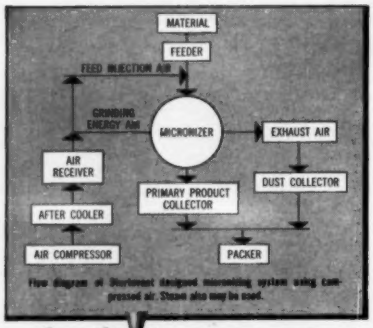
75 pounds in a single stage.

NASH ENGINEERING COMPANY

312 WILSON, SO. NORWALK, CONN.

Need ½ to 44 Microns?

Sturtevant Micronizers* Make 325 Mesh Obsolete



Flow diagram of Sturtevant designed micronizing system using compressed air. Steam also may be used.

Production Model (15 in. chamber)

One Operation Reduces, Classifies

Sturtevant Micronizers grind and classify in one operation in a single chamber—provide fines in range from ½ to 44 microns to meet today's increased product fineness needs. Can handle heat-sensitive materials.

No Attritional Heat

Particles in high speed rotation, propelled by compressed air entering shallow chamber at angles to periphery, grind each other by violent impact. Design gives instant accessibility, easy cleaning. No moving parts.

Classifying is Simultaneous

Centrifugal force keeps oversize material in grinding zone, cyclone action in central section of chamber classifies and collects fines for bagging. Rate of feed and pressure control particle size.

Eight Models Available

Grinding chambers range from 2 in. diameter laboratory size (¼ to 1 lb. per hr. capacity) to large 36 in. diameter production size (500 to 4000 lbs. per hr. capacity). For full description, request Bulletin No. 091.

Engineered for Special Needs

A 30 in. Sturtevant Micronizer is reducing titanium dioxide to under 1 micron at feed rate of 2250 lbs. per hr. For another firm, a 24 in. model grinds 50% DDT to 3.5 average microns at a solid feed rate of 1200-1400 lbs. per hr. A pharmaceutical house uses an 8 in. model to produce procaine-penicillin fines in the 5 to 20 micron range. Iron oxide pigment is being reduced by a 30 in. Micronizer to 2 to 3 average microns.

Sturtevant will help you plan a Fluid-Jet system for your ultra-fine grinding and classifying requirements. Write today.

Can Test or Contract Micronizing Help You?

Test micronizing of your own material, or production micronizing on contract basis, are part of Sturtevant service. See for yourself the improvement ultra-fine grinding can contribute to your product. Write for full details. STURTEVANT MILL CO., 100 Clayton St., Boston, Mass.

*REGISTERED TRADEMARK OF STURTEVANT MILL CO.

LITERATURE . . .

Liquid Seals.....Bulletin SM-27-59 is the latest revision describing Metex high-temperature liquid seals for fractionating trays. Temperatures to 900 F.
192A Metal Textile Corp.

Lining.....PLIOWELD super-tough lining defies the destructive action of a wide range of abrasives and corrosives. Information available on request.
59 *Goodyear, Industrial Products Div.

Metals.....Illustrated brochure describes solid & clad base metals, solid & clad precious metals, thermostat metals, electrical contacts, & industrial metals.
192B Metals & Controls Div.

Mineral Filler.....Celite diatomite absorbs its own weight of liquid . . . yet stays' dry'. Technical data on specific mineral filler or filtration problems.
193 *Johns-Manville

Packings.....Chempro Braided Teflon packings available in all sizes in standard 1/16" increments from ⅛" to ¾" square in spool or coil forms. Rev. Bul. CP-552.
L188 *Chemical & Power Products

Protective Coatings.....Kerpon minimizes corrosion in tanks, vats, pipes, etc. Protects against highly concentrated acids, fumes, caustics, etc. Information.
R211 *Kerr Chemicals, Inc.

Protective Coatings.....Tygon Data Book contains complete application details plus helpful information on performance of Tygon Paint over a wide range of corrosives.
34 *U. S. Stoneware

Protective Coatings.....for steel tank linings, concrete floors, tank cars, etc. Selection of coatings & other Plasite Products covered in booklet.
R162 *Wisconsin Protective Coating Co.

Rubber Linings.....for tanks, pipe & process equipment. Permanent protection against corrosion & contamination. Permanent rubber-to-metal bond. Cat. No. 7115.
132 *Raybestos-Manhattan, Inc.

Stainless Steel.....17-4 PH special-hardening stainless steel combines high strength & hardness at temperatures to about 600 F. with excellent resistance to corrosion.
189 *Armco Steel Corp.

Stainless-Clad Steel.....Bulletin on clad steels is available. Application Research can help you find the right steel plate for the job. Send for your copy.
151 *Lukens Steel Co.

Tantalum.....is close to 100% pure, chemically. Produced by the consumable-electrode process. Practically inert to a wide variety of corrosive media. Details.
145 *Haynes Stellite Co.

Wire Cloth.....A 94-page catalog & stock list gives the full range of wire cloth available, describes fabrication facilities & gives useful metallurgical data.
74 *Cambridge Wire Cloth Co.

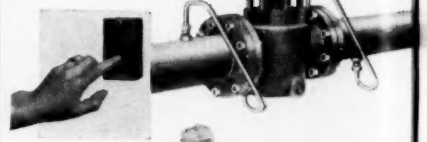
Wire Cloth.....For corrosive service, cloth with accurate mesh count, close tolerance wire diameter, precision weaving, etc. Bulletin F-C has details.
154 *Newark Wire Cloth Co.

*From advertisement, this issue

Jacketed PLUG VALVES

Air Operated

ROTARY TYPE



BEATS MAN-POWER *every time*

for SPEED, SAFETY, CONVENIENCE

Parks-Cramer jacketed plug valves can now be supplied for air or hydraulic operation. Actuators are either cylinder or rotary type depending on degree of rotation, torque and indexing sequence required.

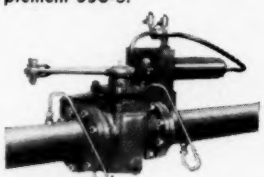
Multiport valves can be arranged to stop at any predetermined position, and to proceed from one position to another in any sequence manually or automatically.

Remote control stations with port position indicating lights can be supplied as required.

For hazardous locations, explosion proof accessories can be furnished.

Actuators are mounted directly on the valve—brackets or bracing from adjoining pipe or building is not required. Linkage to valve stem is direct through couplings or levers—clumsy rack and pinion gearing not needed.

For complete description, details and dimensions, send for our new catalog supplement 356-S.



CYLINDER TYPE

Parks-Cramer Co.
FITCHBURG 13, MASS.

New Subscription Application

Subscriptions Accepted Only From CPI Engineers, Technical Management and Senior Students. Cards Must Be Filled-In Completely Before Service Starts — Students Please Include Class, Major Field and School.

*Rates for U. S. and U. S. Possessions Only**

3 years of CHEMICAL ENGINEERING for $5 ☐

**Foreign—1 Yr.: Canada $4 West. Hem. $15 • Others $25*

☐ √ **HERE for 1 YEAR @ $3**

☐ *Bill me*
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*Rates for U. S. and U. S. Possessions Only**

3 years of CHEMICAL ENGINEERING for $5 ☐

**Foreign—1 Yr.: Canada $4 West. Hem. $15 • Others $25*

☐ √ **HERE for 1 YEAR @ $3**

☐ *Bill me*
☐ *Bill my company*
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☐ Manufacturer
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Product(s) _____

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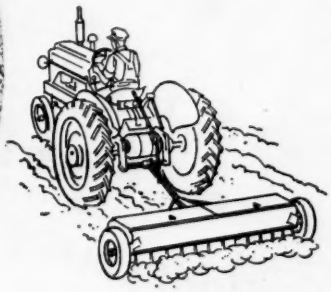
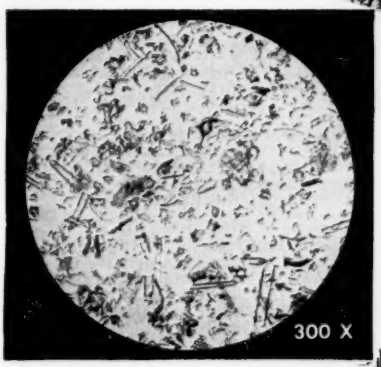
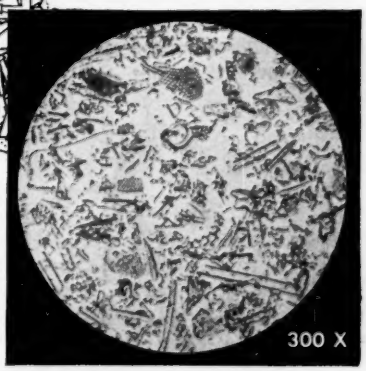
For fertilizer coating—Celite 379, a natural milled diatomite, provides the uniform conditioning needed to prevent caking of granular, mixed or prilled fertilizers—maintains good free-flow characteristics even after prolonged storage.





For catalyst carriers—Super Floss, finest particle size flux-calcined Celite grade, is used where a non-reactive porous silica support is needed. (Also available: special Celite supports in many preformed shapes for strength, high temperature stability, resistance to abrasion and attrition.)

As a paint-flatting agent—Celite 281, air-floated fines of flux-calcined diatomite, provides uniform and efficient flatting at low cost. Contributes to control of low angular sheen, durability, and faster drying.



In diatomites, Johns-Manville precision processing works for you

Celite diatomite absorbs its own weight of liquid . . . yet stays 'dry'

No matter which of the many available grades you choose, you can depend on a given volume of inert Celite* to retain its typical dry-powder characteristics even after absorbing its own weight of liquid.

Actually, Celite can absorb a total of more than twice its own weight. That's because a mass of the fine skeletal particles is approximately 93% air space or voids. Yet, in spite of this very high porosity, Celite is essentially non-hygroscopic.

Other unique properties—extremely high bulk, irregular particle shape and large available surface area—ideally suit Celite to hundreds of mineral filler applications. It is produced with precision from the world's purest commercially available diatomite deposit. It offers a wide choice of grades, each carefully controlled for complete uniformity.

For technical data on specific mineral filler or filtration problems, talk to your nearby Celite engineer. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

*Celite is Johns-Manville's registered trademark for its diatomaceous silica products

JOHNS-MANVILLE

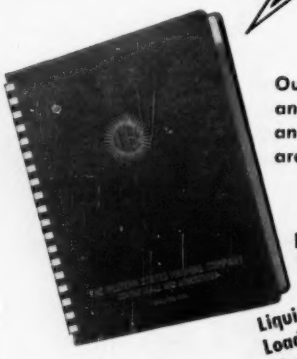
JOHNS-MANVILLE JM PRODUCTS

ROBERTS CENTRIFUGALS for CPI

2648

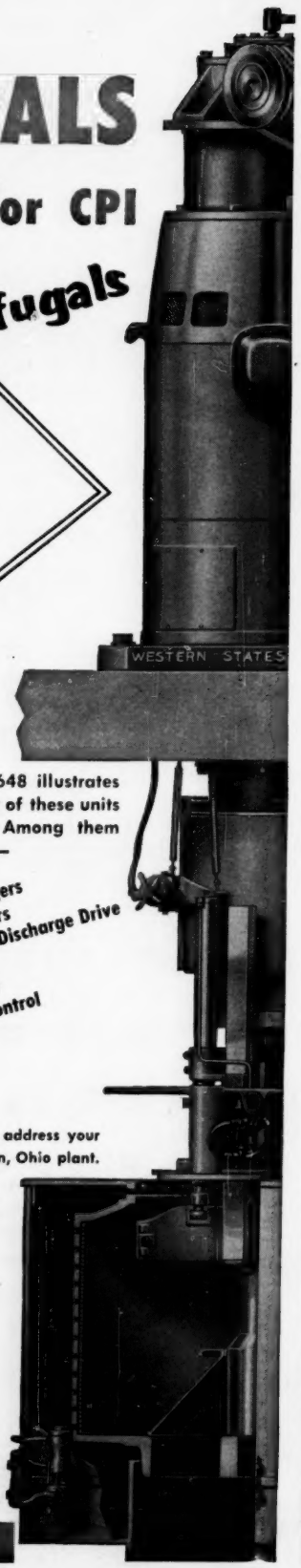
Could be — Your Present Centrifugals Can Be Modernized

Time tested "Roberts" accessories are available for application to your existing suspended type machines. Increase production, improve quality, reduce operator hazards.



Our Booklet No. 2648 illustrates and describes many of these units and applications. Among them are the following —

- Automatic Dischargers
- Handair Dischargers
- Turntork Reverse Discharge Drive
- Liquid Vapor Seal
- Load Measuring Device
- Wash Manifold and Control
- Centrifugal Baskets
- Basket Linings



YOU may have a copy of Booklet No. 2648 free. Please address your request to our Chemical Machinery Division at the Hamilton, Ohio plant.

ROBERTS is the QUALITY name in CENTRIFUGALS

ROBERTS STEVENS

The **WESTERN STATES** MACHINE COMPANY

General Offices and Plant
1700 Fairgrove Avenue
HAMILTON, OHIO, U.S.A.

LITERATURE . . .

Electrical & Mechanical

Casters & Wheels.....Feature rubber treads, rust-proofed, string guards and lubrication. A manual outlining all features in detail is now available.
R203 *Darnell Corp. Ltd.

Circuit Breakers.....Complete and diversified line of molded-case circuit breakers is covered in illustrated bulletin. Ratings, specifications, characteristics.
194A I-T-E Circuit Breaker Co.

Drive.....Bulletin 3600 outlines the Allispede Drive. Available in sizes up to 30 hp, output speeds from 1 to 10,000 rpm, & speed ranges up to 8:1.
27 *The Louis Allis Co.

Drive, Screw Conveyor.....a complete package drive with quick-removable Driving Shaft. Available from stock with 5 different size shafts. Technical data in bulletin.
174 *Dodge Mfg. Corp.

Drives & Couplings.....Bulletin on Dyna-V drives selection data, Paraflex couplings data & Flexidyne drives & couplings are available on request.
175 *Dodge Mfg. Corp.

Electric Power Drives.....Catalog 258 gives prices, dimensions and modifications for motors, speed reducers, gearmotors and variable speed drives. Ratings to 200 hp.
194B Sterling Electric

Motor Control.....A complete line of low voltage control (size 0 through 8) and high voltage control in all NEMA enclosures, plus engineered control systems. Details.
53 *Allis-Chalmers

Motor-Starter Combinations.....polyphase open-type, totally-enclosed, or explosion-proof motors and magnetic increment starters. Bulletins MU-128 and MU-195.
133 *Wagner Electric Corp.

Motors.....New data on the complete line of C-W Sealedpower motors is given in Bulletin PB 6000-2. Effective sealing gives motors better protection against dust, etc.
196 *Elliott Co.

Nozzles.....Norbide pressure blast nozzles are available with bores from ⅛" to ⅞"; lengths up to 6". Complete details available on your request.
13 *Norton Co., Refractories Div.

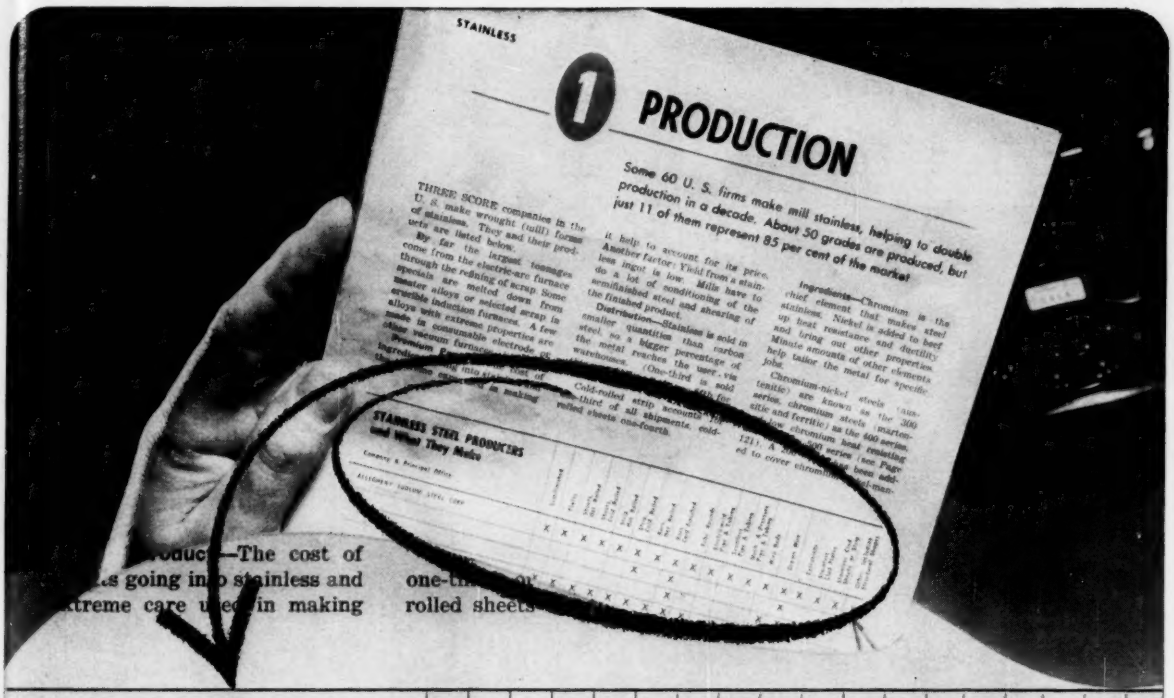
Turbines.....A complete range of power-packed turbines from 1 HP to 250 HP. Further facts on turbines contained in the new Catalog 200.
49 *Coppus Engineering Corp.

Handling & Packaging

Bulk Trucks.....Complete information on how Sprout-Waldron pneumatic bulk trucks may fit your application is contained in Bulletin 205. Available on request.
186 *Sprout-Waldron & Co.

* From advertisement, this issue

Experience**—the added alloy in **A-L Stainless, Electrical and Tool Steels


STAINLESS
1 PRODUCTION
Some 60 U. S. firms make mill stainless, helping to double production in a decade. About 50 grades are produced, but just 11 of them represent 85 per cent of the market
THREE SCORE companies in the U. S. make wrought (mill) forms of stainless. They and their products are listed below.
By far the largest tonnages come from the electric-arc furnace through the refining of scrap. Some specials are melted down from master alloys or selected scrap in erectable induction furnaces. A few alloys with extreme properties are made in consumable electrode vacuum furnaces.
Premium
Ingredients—Chromium is the chief element that makes steel stainless. Nickel is added to beef up heat resistance and ductility and bring out other properties. Minute amounts of other elements help tailor the metal for specific jobs.
Chromium-nickel steels (austenitic) are known as the 300 series. chromium steels (martensitic and ferritic) as the 400 series.
STAINLESS STEEL PRODUCERS and What They Make
Company & Principal Office
Allegheny Ludlum Steel Corp.

STAINLESS STEEL PRODUCERS and What They Make Company & Principal Office	Semifinished	Plates	Sheets, Hot Rolled	Sheets, Cold Rolled	Strip, Hot Rolled	Strip, Cold Rolled	Bars, Hot Rolled	Bars, Cold Finished	Tube Rounds	Electricweld Pipe & Tubing	Seamless Pipe & Tubing	Mech. & Pressure Pipe & Tubing	Wire Rods	Drawn Wire	Extrusions	Stainless Clad Plates	Stainless Clad Sheets or Strip	Other, Including Structural Shapes
ALLEGHENY LUDLUM STEEL CORP. Pittsburgh	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
						X		X						X				

Of the 60 producers of stainless steel...

only ALLEGHENY LUDLUM makes all sizes, shapes, finishes and analyses

In its November 4, 1957 issue, STEEL magazine published a complete run-down on the stainless steel industry. This article reveals that *only Allegheny Ludlum*, of the 60 some companies making stainless, produces all sizes, shapes, finishes and analyses.

This can save you considerable time and money. When you make Allegheny Ludlum your *one* source of stainless, you work with *one* sales engineer—*one* order, whether you buy sheet, strip, bars, tubing or whatever.

And, at the same time, you get the best technical service. A-L's crack research and development department is continually searching for new alloys, and better ways to use today's. Its findings are freely available to you through sales engineers, technicians and special literature.

Allegheny Ludlum follows the product from the melt through to finished form, has greater quality control over the stainless you buy. And since A-L makes all forms of stainless, you get unbiased recommendations as to what is best for your individual needs.

Profit by Allegheny Ludlum's status as the only one-source integrated supplier of all stainless forms. Call your A-L representative today . . . see how he can save you money and time. Or write ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

7121

ALLEGHENY LUDLUM

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

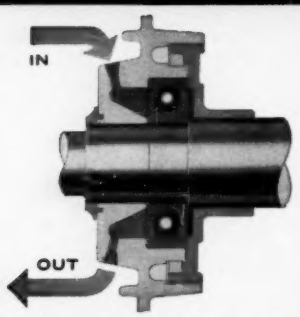
Elliott C-W SEALEDPOWER Motors now available up to 300 hp, in totally-enclosed, fan-cooled and explosion-proof designs

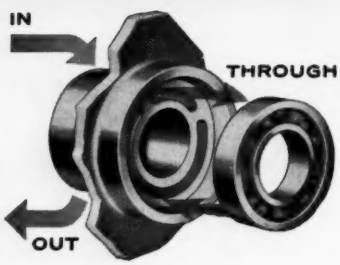
with

ELLIOTT C-W SEALEDPOWER MOTORS

you choose the type of bearings

For most applications, open greasable bearings will serve dependably and economically. But for use where lubrication maintenance is difficult, Elliott offers a pre-lubricated cartridge type which requires no service lubrication.





OPEN GREASABLE BEARING

The drawings show how fresh lubricant, forced through bearings with motor running, positively flushes out old grease. Requires infrequent attention. Advance design prevents over-lubrication and protects against entrance of moisture.

PRELUBRICATED BEARING

No service is required for the Elliott cartridge-type factory-prelubricated bearing. Grease reservoir and internal cap help seal and protect the bearing

GET ALL THE FACTS

about Elliott C-W SEALEDPOWER Motors. New Bulletin PB 6000-2 has interesting data. Send for free copy.

W 9-4

ELLIOTT Company

CROCKER-WHEELER PLANT JEANNETTE, PA.

LITERATURE . . .

Fork Lift Trucks.....Bulletin fully illustrates & describes the Fork Lift Trucks plus accessories and optional equipment. Available on request.
196A Allis-Chalmers

Payloader.....The H-25 is the only loader in its size range with complete power-shift transmission. Power steering also is standard. Data on request.
57 *The Frank G. Hough Co.

Pneumatic Bulk Truck.....Complete details on bulk trucks for handling and delivery of a variety of chemicals contained in Bulletin 205-A. Available now.
161 *Sprout-Waldron

Pneumatic Conveying System..... Literature describing Pneumatic Conveying Pumps, Air Activated Containers, Air-Float Air-Gravity Conveyors, Installation.
85 *Kennedy Van Saun

Screw Conveyor Line.....Quik-Link conveyor screw, hangers, trough ends, countershaft ends, troughs, drives, etc. are completely covered in Book 2989.
15 *Link-Belt

Vibrating Equipment.....features rugged, sanitary construction plus Natural-Frequency drive to assure gentle conveying & to prevent product damage or degradation.
165 *Carrier Conveyor Corp.

Heating & Cooling

Air Cooled Condensers.....Standard sizes from 7½ to 100 tons based on 120° condensing temp. 40° suction 100° ambient. Complete facts on request.
32 *Buffalo Forge Co.

Blast Heaters.....Wide range of sizes furnished with or without pressure blowers. Compact cast iron design requires less space. Complete story in Catalog 956.
200b *D. J. Murray Mfg. Co.

Chlorinator.....The V-notch chlorinator offers safe chlorine control. Booklet, "The V-notch Story" tells all about the many features.
212 *Wallace & Tiernan Inc.

Condensers.....Design and construction of Type F surface condensers are described and illustrated in Bulletin C-10. Tables, curve and example illustrate performance.
196B Elliott Co.

Condensers & Heat Exchanger Tube.....Complete information contained in Condenser & Heat Exchanger Tube Handbook which is now available on request.
26 *Bridgeport Brass Co.

Cooling Towers.....“Test Your Tower” details the Marley method of tower testing, & “Analyze Your Bids” presents a logical means of prepurchase evaluation.
72 *The Marley Co.

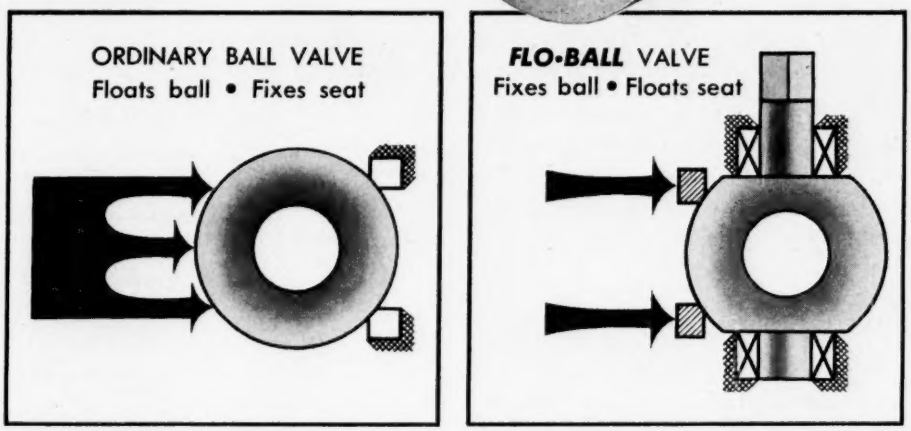
Cryogenic Equipment.....Equipment to store, handle and transport low-temperature liquid gases is topic of 16-page bulletin. Includes photos and typical specifications.
196C Standard Steel Corp.

* From advertisement, this issue

Only *FLO•BALL* valves are "Bearing-Fixed" for maintenance-free long life!

...with all the features you must have:

- **Top loading**
- **Replaceable seats**
- **One-piece ball and stem**
- **90° on-off**
- **Two-way flow**



Floating ball puts excessive pressure load on fixed seats. Results in distortion and short life.

FLO•BALL **bearings absorb all pressure forces. Elimination of excessive seat loading insures long life.**

The ***FLO•BALL*** is competitively priced in all materials and sizes through 10″ in 150 lb. and 300 lb. class. Write today to Hydromatics for full information on this extraordinary valve.

FLO-BALL

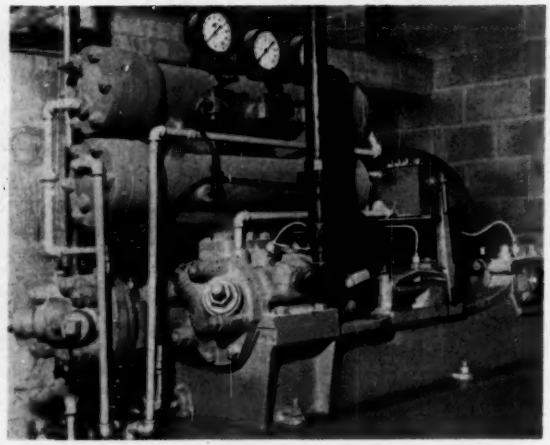
Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX = LIVINGSTON, N. J. 120

Copyright 1960 Hydromatics, Inc.

Exceptional engineering employment opportunities—write today!

THIS
NORWALK ACETYLENE COMPRESSOR
In Use for Over 42 Years



This three stage, 6 × 6 Norwalk compressor #2618 was built during World War I and delivered to Canadian Liquid Air Co., Ltd., Canada. It has been producing acetylene ever since, currently at this company's Kitimat, British Columbia plant. Throughout the years Norwalk has been able to furnish its essential repair parts.

Every Norwalk compressor is test-run at the factory, then taken down for complete inspection before reassembly and shipment. Norwalk makes compressors from single stage to six stages, from 125 to 25,000 psi pressure, for gases as follows:

ACETYLENE	ETHYLENE
AIR	HCL
ARGON	HELIUM
CERTAIN HYDRO CARBONS	HYDROGEN
	NITROGEN
CO AND CO_2	NITROUS OXIDE
ETHANE	OXYGEN

For full details, write for Catalog 44

NORWALK COMPANY, INC.

SOUTH NORWALK, CONNECTICUT

Established 1864

LITERATURE . . .

Dryers.....Drying Systems with proven efficiency in processing chemicals, foods, pharmaceuticals, tobacco, synthetic rubber, textile fibers, veneers, etc. Bul. #443.
143 Proctor & Schwartz, Inc.

Fluid-Bed Dryer.....Bulletin 81 covers the design, operation, advantages and applications of Raymond fluid-bed drying systems. Illustrations shows typical etc.
198A **Combustion Engineering, Inc.**

Heat Exchangers.....designed for 2500 lbs. operating pressure on both shell and tube sides. All stainless 304 material. Bulletin 58E is offered.
71 *Graham Mfg. Co., Inc.

Heat Exchangers.....Bulletin on Karbate impervious-graphite immersion heat exchangers and circulating steam jets for heating or cooling corrosive solutions offered.
198B National Carbon Co.

Heat Transfer.....The new Multi-Zone Platecoil introduces a new principle of coil design. Solves tough tank & process heating problems. Data in Bul. P61.
65 *Tranter Mfg. Co.

Heat Transfer Equipment.....Bulletin HE-8 describes and illustrates construction details of the manufacturer's line of standard and special heat exchangers.
198C Henry Vogt Machine Co.

Heat Transfer Units.....Details on engineering, fabrication and erection for guaranteed heat transfer equipment is available now on request.
225 . *Chicago Bridge & Iron Co.

Heating Systems.....Information booklet on Aroclor 1248 heating systems and guide to heater selection is available. Its compact design saves space.
152 *Monsanto Chemical Co.

Kilns, Rotary.....have all welded steel shells, feed & discharge end seals, heat recuperating chain systems for wet process kilns, improved kiln feeders, etc. Bul. 1115.
25 *Traylor Engr. & Mfg. Co.

Radiators.....for use in confined areas where motorized units are not desirable. For low or high pressures to 250 PSI. Additional information in Catalog 956.
200c * D. J. Murray Mfg. Co.

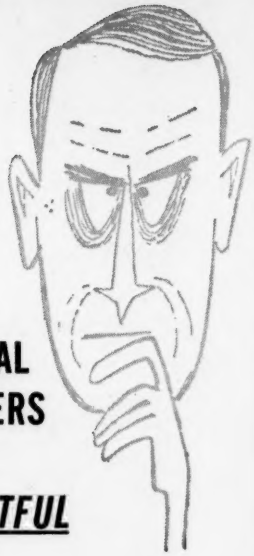
Refrigeration.....Bulletin 631 describes the Uni-Chiller. Also if you have a refrigeration or pressure vessel application, a review of your problem is available.
202 *The Vilter Mfg. Co.

Scraped Surface Exchangers.....solve special heat transfer & crystallization problems. Units fabricated from a broad range of materials. Literature.
119 *Henry Vogt Machine Co.

Steam Trap.....The 48-page Book contains additional information on trap capacity ratings, plus data on how to correctly size, install & maintain steam traps.
33 *Armstrong Machine Works

Steam Trap.....Impulse Traps test for condensate in the line ahead of the trap & operate to discharge it as soon as it forms. Bulletin "The Why and How of Steam Trapping."
131 *Yarnall-Waring Co.

* From advertisement, this issue



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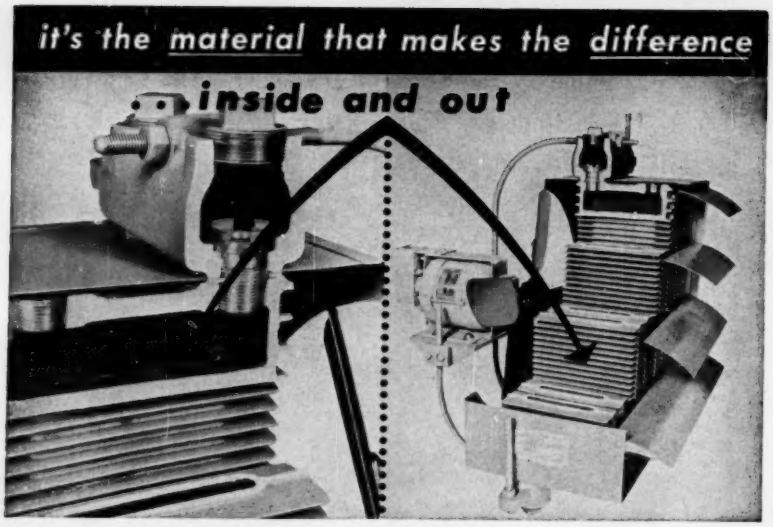

CORROSION - Inside and Out - causes heating equipment failures!

BUT NOT WHEN YOU USE **GRID**

cast iron construction

- UNIT HEATERS
- BLAST HEATERS
- RADIATORS

CORROSION internally, caused by electrolytic action as in copper tubes, can't happen in GRID's cast iron steam chambers and headers. Nor can acid condensate corrode the bottom connections. Cast iron, internally, resists corrosion.

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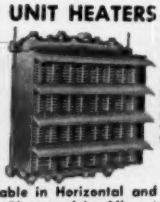
Send for Catalog 956 . . . The complete story on Grid Unit Heaters, Blast Heaters and Radiators

Designed for operation on steam pressure up to 250 PSI 450° temperature

INSTALL **GRID** CAST IRON

UNIT HEATERS



Available in Horizontal and Down Blow models. All cast iron built for steam pressures up to 250 PSI 450 Degrees.

BLAST HEATERS

Wide range of sizes furnished with or without pressure blowers. Compact cast iron design requires less space.

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Various combinations with or without Grill covers. For use in confined areas where motorized units are not desirable. For low or high pressures to 250 PSI.

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LITERATURE . . .

Steam Traps.....Informative booklet on steam traps and condensate drainage covers sizes from ½ to 2 in. bronze and semisteel, and ½ to ¾ cast steel. To 250 psi.
200A Barnes & Jones, Inc.

Unit Heaters.....are available in Horizontal & Down Blow models. All cast iron built for steam pressures up to 250 PSI 450 Degrees. Catalog 956.
200a *D. J. Murray Mfg. Co.

Instruments & Controls

Analyzer - Recorder.....Measures & records excess air & the mixing efficiency of your fuel-burning equipment. Details in Product Specifications E65-1 & E12-5.
156 *Bailey Meter Co.

Controls.....Publication contains information on the complete line of control devices offered by manufacturer. Selection charts on motors, relays, solenoids, etc.
200B **General Electric**

Controls.....Handbook, "Modern pH and Chlorine Control" gives theory and application of pH control. Illustrates & describes full line. Available on request.
R209 *W. A. Taylor & Co.

Density Controller.....Bulletin LSG describes operation, specifications and advantages of density controller for use with dryers, evaporators, thickeners, etc.
200C The Ohmart Corp.

Dust Control.....Pamphlet discusses methods of collecting and measuring aerosols and dusts from ducts and stacks. Also details dust concentration evaluation.
200D Gelman Instrument Co.

Gauge.....The USG A-line meets A.S.A. Grade A standards, including accuracy of 1%. Wide choice of options. Complete details in Catalog 305.
84-b *United States Gauge

Gauges.....A complete catalogue on high pressure gauges for use in refineries and chemical plants. Includes Gauge Cocks, large chamber reflex gauges, etc.
L162 *Strahman Valves, Inc.

Gauges.....Catalog 1819 contains information on Supergauge, Mono-Unit design and Arc-Loc movement. Details on a comprehensive line of dial pressure gauges.
84-a *United States Gauge

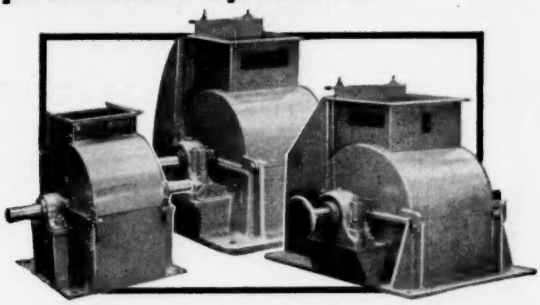
Indicator.....The "Minimite" portable potentiometer indicator gives you laboratory accuracy in a rugged versatile instrument. Details in Bulletin 64-4.
TL211 *Thermo Electric Co., Inc.

Instrumentation.....Consotrol includes control functions for all types of processing requirements—auto-selector . . . cascade & ratio systems. Bul. 13-18.
8-9 *The Foxboro Co.

Instrumentation.....Catalog describes and illustrates instruments for electronic, biological and chemical measurement and control. Specifications, performance data.
200E Keithley Instruments, Inc.

* From advertisement, this issue

M & M chemical and plastic converters have many new features for smoother, more profitable operation



The exclusive design of small staggered and tapered cutting knives in the large cylinder gives the M & M Converter a slicing action instead of chopping or hammering . . . to relieve impact shock from bearings, shaft and basic construction. The large rotating cylinder mounted between heavy-duty roller bearings does not require any flywheel and the well-balanced design of the M & M all-welded steel construction assures trouble-free operation with the least amount of maintenance. These Converters are available in a variety of sizes. Shown are three models which are available with top or side intake and side or bottom discharge.

Write today for complete information.

MITTS & MERRILL

1007 SO. WATER ST. • SAGINAW, MICHIGAN

BUILDERS OF WORK-SAVING, MONEY-SAVING AND MATERIAL RECLAIMING MACHINERY SINCE 1854. 110

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STAINLESS STEEL "MNH" FLEXIBLE CONNECTORS

A NEW stock answer to pipeline problems caused by rigid connections.

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- **CORROSION RESISTANCE . . plus**
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- **FLEXIBILITY**

Also available in Monel, Bronze and Steel.

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1" 1¼" 1½" 2"

IN THESE STOCK LENGTHS

12" 18" 24" 30"
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SHIPPED FROM FACTORY SAME DAY ORDER IS RECEIVED.

Also available in all standard sizes thru 16", in any required lengths, and with any special or standard end fitting or flange connections. Send your problems to Allied's Engineering Department; Let us suggest the best solution for your flexation problems.

ALLFLEX Standard Stainless Steel Connectors are sold through leading Industrial Distributors. If not available locally—*remember* THEY CAN BE SHIPPED FROM FACTORY SAME DAY ORDER IS RECEIVED.

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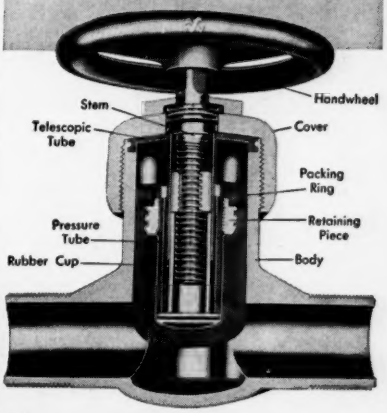
New

ROCKWELL-STUBBE

PLASTIC VALVE Solves Corrosion Problems



1. Simple one-piece body of polyethylene-acrilonitrile butadiene styrene—polyvinyl chloride—polyamide—polycarbonate or other plastics.
2. Valve shuts off TIGHT through pressure applied by telescopic arrangement to natural or synthetic soft rubber cup.
3. Straight-through design—no obstructions in full open position—no pressure loss.
4. No packing gland—no rising stem.
5. Completely vacuum tight.
6. Working pressure—125 psi.
7. Screwed, plain or flanged ends; sizes to 2½".

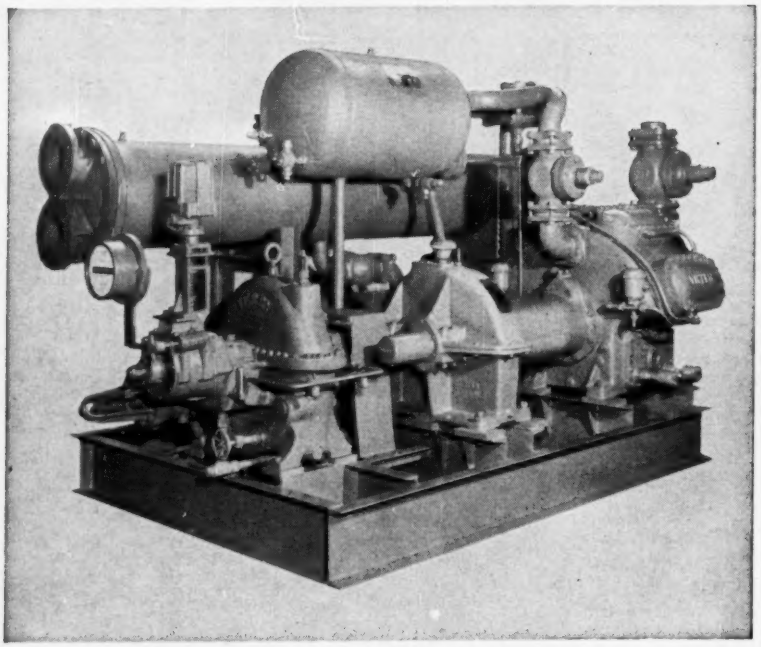
Write for Bulletin 802.

W. S. ROCKWELL CO.

Valves for Industry

2300 Eliot Street
Fairfield, Conn.

Variable refrigeration capacity controls vital chemical reactions



This special Vilter Uni-Chiller has a capacity of 80 tons of refrigeration, operates at 30 degrees suction and 105 degrees condensing temperatures.

Variable refrigeration capacity is of extreme importance in the manufacture of the product of a large southern chemical plant. Vital chemical reactions require holding temperatures within very close tolerances.

However, because the quantity manufactured changes from time to time, great flexibility is demanded of the refrigeration equipment to constantly maintain the proper temperature. This is achieved through a Vilter variable capacity refrigeration system.

Providing this refrigeration flexibility is a special custom-designed Vilter Uni-Chiller which includes: a shell and tube condenser, an eight cylinder compressor, a variable speed turbine operating through reducing gears, explosion proof controls, and special safety components. Varying the turbine speed changes the amount of refrigeration capacity . . . the response is quick.

During manufacturing, the refrigeration circuits are factory assembled and tested, simplifying field installation.

If you have a refrigeration or pressure vessel application, write Vilter for a review of your problem.

Vilter® refrigeration air conditioning

The Vilter Manufacturing Company
Milwaukee 7, Wisconsin

Air Units • Ammonia and Freon Compressors • Booster Compressors Baudelot Coolers • Water and Brine Coolers • Blast Freezers Evaporative and Shell and Tube Condensers • Pipe Coils Valves and Fittings • Pakice and Polarflake Ice machines.

Write for Bulletin 631 to The Vilter Manufacturing Company, Dept. K-903 2217 South First Street Milwaukee 7, Wisconsin

LITERATURE . . .

Instrumentation.....Data sheet covers Speedomax H indicators, recorders and controllers for pH and redox. Lists types of control action obtainable. Specifications.
202A Leeds & Northrup Co.

Liquid Level Control.....is available for controlling level changes from ⅛" to 150 ft. Multi-stage switching when desired. Information on Magnetrol on request.
BL205 *Magnetrol, Inc.

Meters.....Electricontact Meters offer absolute batch or process uniformity. Complete information contained in Catalog which is now offered.
187 ***Buffalo Meter Co.**

Meters, Liquid.....wherever liquids are batched blended or transferred. Complete data on meters for all your needs is contained in Bulletin 566 B.
220 *Neptune Meter Co.

Radiation Detection.....Catalog I-60 displays radiation detection and measuring instruments for industrial applications. Illustrations and prices included.
202B Nuclear Measurements Corp.

Weighing System.....Select-O-Weigh system governs all components required for automatic formulation by weight of any product, liquid or solid. Details.
206 *Richardson Scale Co.

Pipe, Fittings, Valves

Acid Hose.....Giant Acid Hose is made for either suction or discharge service, replacing metal pipe because it handles highly corrosive solutions so well.
147 *United States Rubber

Connectors, Flexible.....MNH flexible connectors dampen vibration, compensate for misalignment, permit offset movement, & absorb expansion. ALLFLEX bulletin.
BL201 *Allied Metal Hose Co.

High-Pressure Equipment.....Features of accessories and tools for use with valves and fittings required by high-pressure systems are given in new 4-page catalog.
202C High-Pressure Equipment Co.

Pipe.....All purpose rigid PVC in schedules 40, 80, & 120, ½ to 4". Threaded or socket-weld fittings. Valves ½ to 2". Send for Bulletin CE-56.
164a *American Hard Rubber Co.

Pipe.....Data on Fluoroflex-lined steel pipe is offered. Features no corrosion, no leakage. Comes in sizes & lengths specified in your piping plan.
43 *Resistoflex Corp.

Pipe, Plastic.....Flexible poly pipe is ideal for water lines, drains, underground pipe or conduit. In sizes ½ to 2", long coils. Details in Bul. CE-57.
164c *American Hard Rubber Co.

Safety Heads.....protect relief valves against corrosion and plugging. If you have corrosion & plugging problems with your relief valves information is offered.
158 *Black, Sivalls & Bryson, Inc.

* From advertisement, this issue

A UNIQUE CHECK VALVE THAT'S UNSURPASSED IN WATER, AIR, OIL OR GAS SERVICE

SILENT • SEATLESS • LOW PRESSURE DROP

Technocheck©

OUTPERFORMS • OUTWEARS OTHER VALVES • COSTS LESS TO MAINTAIN

In field service in a wide range of water, gas, air and oil applications, Technocheck's performance and reliability are unsurpassed. Its exclusive design eliminates valve seats. Tight sealing, low pressure drop and long life with low upkeep are some of its important characteristics.

SCHEDULE OF STANDARD VALVE SIZES

GENERAL DESCRIPTION	PSI	SIZES
Cast Iron, Flanged	125	4", 6", 8"
Steel, Male Threaded Ends	150	1½", 2", 2½", 3"
Steel, Flanged	150	3", 4", 6", 8"
PVC, Male Threaded Ends	125	1½", 2", 3"
PVC, Flanged	125	2", 3"
PVC, Flanged	50	4", 6", 8"

We invite inquiries on other sizes and in special materials.

Techno Corporation Dept. CE
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NEW SPRAY-ON FLUORESCENT PENETRANT

Finds ALL Cracks, Pores, Leaks IN NONMAGNETIC MATERIALS

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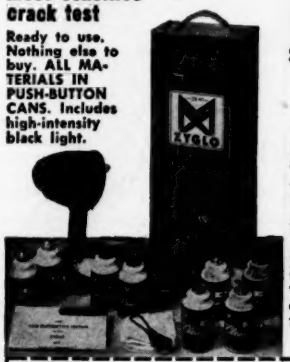
$125.00 F.O.B. CHICAGO PLANT. Local taxes extra. Continental U.S.A. only.

most sensitive crack test

Ready to use. Nothing else to buy. ALL MATERIALS IN PUSH-BUTTON CANS. Includes high-intensity black light.



Utilizes Zyglo ZL-22, developed for supersensitive testing of jet engine and missile parts. Finds defects nothing else will find and marks them right on part. Gives you versatile, cheap, on-the-spot testing for pilot runs, tools, critical areas of big parts, limited run production, etc. Order now —*pin this ad to your letterhead or P.O.*—or write for full facts today.

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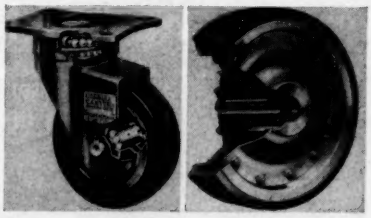
DARNELL CASTERS AND WHEELS

Built to take it... Indefinitely!



designed to suit your every need

RUBBER TREADS . . . a wide choice of treads suited to all types of floors, including Darnelloprene oil, water and chemical-resistant treads, make Darnell Casters and Wheels highly adapted to rough usage.

RUST-PROOFED . . . by zinc plating, Darnell Casters give longer, care-free life wherever water, steam and corroding chemicals are freely used.

LUBRICATION . . . all swivel and wheel bearings are factory packed with a high quality grease that "stands up" under attack by heat and water. Quick grease-gun lubrication provides easy maintenance.

STRING GUARDS . . . Even though string and ravelings may wind around the hub, these string guards insure easy rolling at all times.

Write today for the complete story

NEW MANUAL

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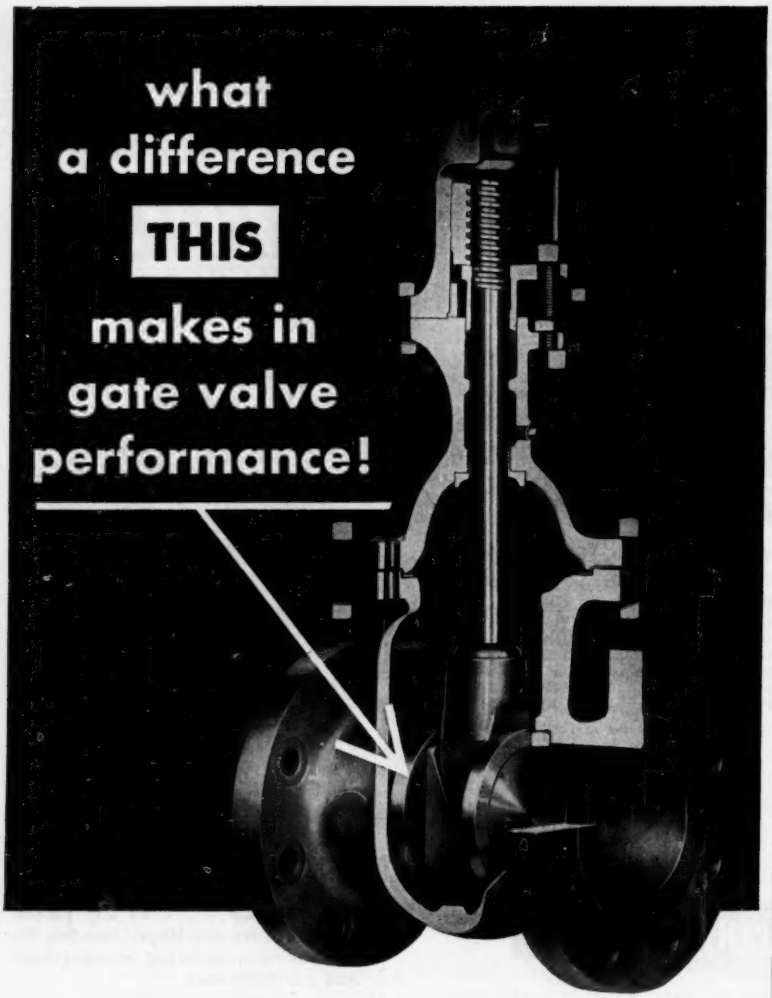
36 NORTH CLINTON STREET, CHICAGO 6, ILLINOIS

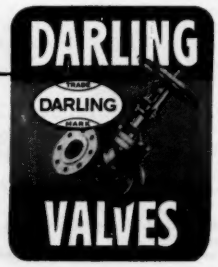


LONGER valve life, less maintenance and process interruption, positive closure, easier operation, self-adjustment for valve body deflection. These are some of the well proved advantages gained as a result of the Darling *fully revolving double disc parallel seat* principle!

These Darling valves are made in various alloys, types and sizes for most services . . . and for all pressures. Send for Catalog No. 57. You'll see what we mean by exceptional performance.

ENGINEERING SERVICE: Darling offers unusual facilities for the development and manufacture of special valves for out-of-the-ordinary requirements. This special service is available to you at all times, without obligation.

DARLING VALVE & MANUFACTURING CO.
Williamsport 3, Pa.
Manufactured in Canada by
Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.



LITERATURE . . .

Tubing.....Complete information on Nuclear and Super corrosion-resistant tubing contained in Metal Tubing Handbook, Corrosion Chart, & Damascope Inspection Bulletin.
224 *Damascus Tube Co.

Valve.....New Type G Sleeveline is a non-lubricated plug valve. For sulfuric acid service, caustic service, solvent handling, etc. Bulletin V/12.
135 *The Duriron Company, Inc.

Valve.....In field service in a wide range of water, gas, air and oil applications. Information on all sizes & special materials of Technochecks is offered.
TL203 *Techno Corp.

Valve.....The new plastic valve shuts off tight through pressure applied by telescopic arrangement to natural or synthetic soft rubber cup. Bulletin 802.
R201 *W. S. Rockwell Co.

Valve.....Non-lubricated "O-Seal" valve is guaranteed not to stick. Complete range of sizes and types available. Complete details on request.
24 *Wedgeplug Valve Co.

Valve, Butterfly.....Bulletin 10AJ illustrates and describes the new Monoflange Mark II rubber seat butterfly valve. Complete specifications, including prices.
204A Henry Pratt Co.

Valve, Check.....The Basic-Check unit is available in seven standard line sizes from ¾" to 2". Full information about these unique check valves in Bul. CE10.
173 *Durabla Mfg. Co.

Valve, Slurry.....Bulletin describes new quick-acting slurry valve. Features include an open valve chamber and wedge-shaped moving parts. Sizes to 6 in.
204B Everlasting Valve Co.

Valves & Fittings.....have high burst strength. All parts made of plastic. Newest literature on the complete line of PVC Valves & Fittings is now available.
28 *Walworth

Valves.....Bulletin describes the Atlas No. 171 Type D valves, which can be used as pressure reducing or relief valves or pump governors with oil, steam, water, gas.
204C Atlas Valve Co.

Valves.....Booklet describes Circle Seal line of valves. Contains technical data, construction details, materials and operating principles. Ordering information.
204D Circle Seal Products Co.

Valves.....The Flo-Ball in all materials & sizes through 10" in 150 lb. and 300 lb. class. Full information on this extraordinary valve is available.
197 *Hydromatics Inc.

Valves.....Newly revised version of comprehensive 500-page valve catalog is offered by manufacturer. Features 24-page valve selector. Code requirements, references.
204E Lunkenheimer Co.

Valves, Ball.....In chemicals, paper, rubber, petroleum, aircraft, & missiles, they handle a wide range of liquids & gases. "At Your Service" Literature offered.
127 *Jamesbury Corp.

*From advertisement, this issue

Protects Metals Against Hot Acids, Acid and Sulfurous Fumes, Salt Spray, Steam, Mild Alkalies, Up to 600° F.

Markal "D-A" Coatings will protect metal against any corrosive action. It is an ideal product for ore sintering plants, plating plants, food plants, lumber kilns, foundries, chemical plants, sewage disposal plants, laundries, heat exchangers . . . many others.

Markal "D-A" Coatings are applied by brush or spray and can be air dried or baked. The Coatings will withstand temperatures up to 600°F.

For free sample write on company letterhead, stating temperature extremes, surface temperature at time of application, and corrosive condition.

Other Markal Coatings are available in a complete range of types for any condition and temperatures up to 2200°F. Send for catalog No. MPC.

The Markal Company, 3106 West Carroll Avenue, Chicago 12, Ill.
Telephone SAcramento 2-6085

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permanent magnetic force...

A sleeve, raised and lowered within a nonmagnetic tube, attracts or releases an Alnico magnet attached to the mercury (or dry contact) switch. Basically, this is Magnetrol.

The operating principle behind MAGNETROL LIQUID LEVEL CONTROL

Because its operating principle, based on the proper use of a permanent magnet, guarantees a perpetual guardianship over your critical liquid levels, the Magnetrol liquid level control unobtrusively takes the most important place in any system or process where it is necessary to keep a liquid at a constant level. Principle and action are so simple that failure is virtually impossible. Magnetrol is versatile, too—will handle almost ANY liquid, at ANY temperature, at ANY pressure, with the same precision and dependability. No mechanical or electrical linkages to stick, bind, ride out of line or wear out. Available for controlling level changes from ⅛" to 150 ft. Multi-stage switching when desired. Write to

MAGNETROL, Inc., 2124 S. Marshall Blvd., Chicago 23, Illinois

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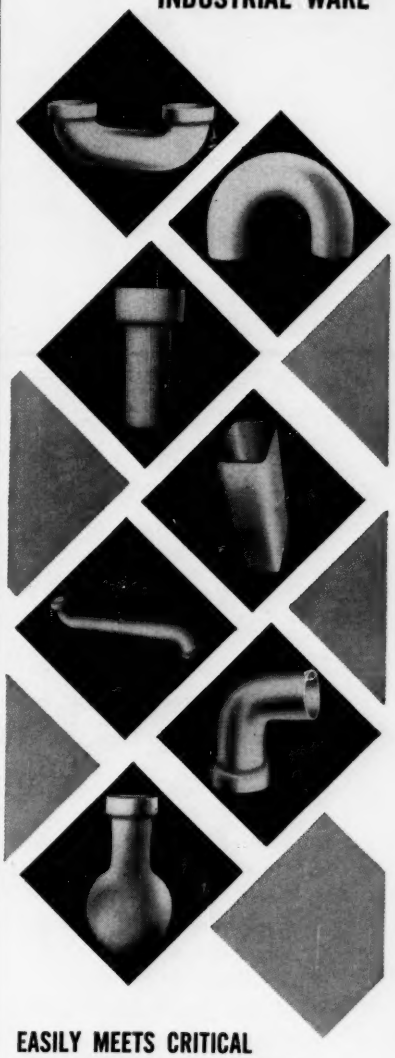
PURE FUSED QUARTZ INDUSTRIAL WARE



EASILY MEETS CRITICAL PRODUCTION REQUIREMENTS

- Absolute Chemical Purity
- Extreme Heat Resistance
- Thermal Shock Resistance
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- Outstanding Electrical Properties
- Full Range Radiant Energy Transmission

Many standard shapes and sizes . . . and we fabricate for special needs. See our ad in **Chemical Engineering Catalog.**

Write for complete, illustrated catalog.

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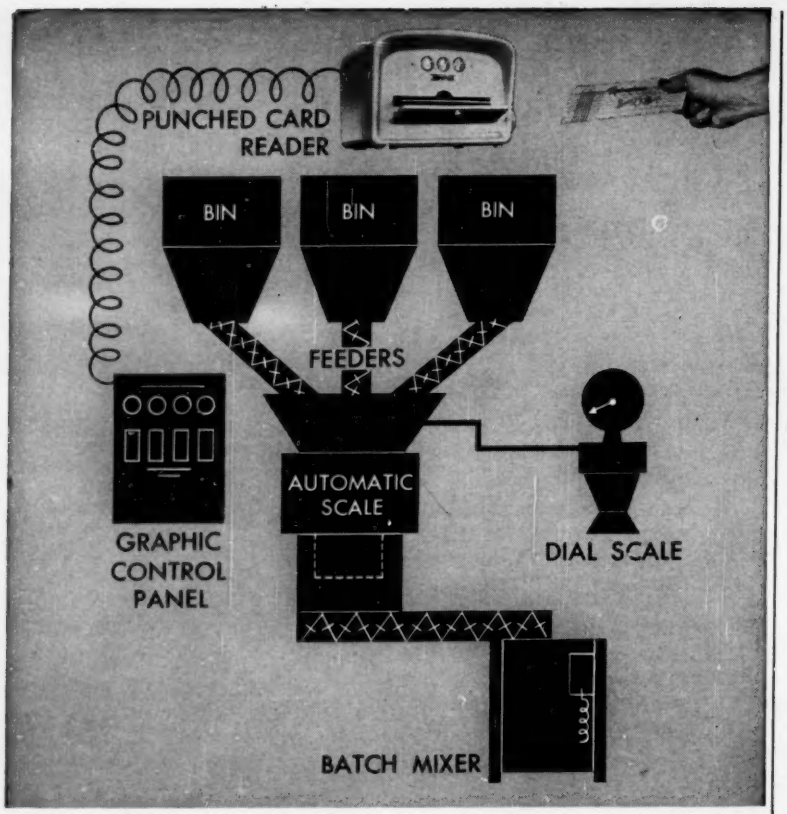

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AUTOMATES

FROM BIN TO BATCH

The Richardson Select-O-Weigh system governs all components required for automatic formulation by weight of any product, liquid or solid, involving any number of ingredients.

Programming – by a Punched Card Reader or alternate control systems

Flow Control and Indication – at one remote control panel, housing complete process circuitry

Feeding – feeders engineered for specific materials and needs

Weighing – by Richardson Automatic Scale, accurate to 1/10 of 1%

Mixing – of ingredients in completed batch

Readout – counters, totalizers, printers, typewriters, recorders of all types

When required, service is available from Richardson's nationwide network of service facilities . . . within 24 hours. Custom-engineered by the world's foremost manufacturer of automatic weighing and proportioning equipment, Select-O-Weigh helps you make a better, more uniform product, at lower cost. For full details write, wire or call today.

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RICHARDSON SCALE COMPANY • CLIFTON, NEW JERSEY

Sales and Service Branches in Principal Cities

Also Manufactured in Europe to U.S. Standards

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LITERATURE . . .

Valves, Gate.....are made in various alloys, types & sizes for most services...and for all pressures. Catalog No. 57 is available on request. Send for your copy.
204 *Darling Valve & Mfg. Co.

Valves, Packless.....Highly informative Catalog AH-F shows the wide range of packless valves. Feature bellows of brass, phosphor bronze, monel or stainless steel.
178 *Robershaw-Fulton Controls

Valves, Plug.....Jacketed plug valves can be supplied for air or hydraulic operation. Complete description, details & dimensions in new catalog supplement 356-S.
192 *Parks-Cramer Co.

Valves, Safety-Relief.....Complete information is provided in Catalog FE-118, covering both selection & sizing of Farris process Safety-Relief Valves.
171 *Farris Engineering Corp.

Valves, Solenoid.....in conduit type and grommet type. Port sizes ⅛" and ¼" NPT. Ten orifice sizes 3/64" through ¼". Wide range of voltages. New bulletin.
BL211 *Marsh Instrument Co.

Valves, Solenoid.....are covered in an 8-page article entitled, "How To Specify Solenoid Valves." It includes diagrams and charts on the different series.
206A Valcor Engineering Corp.

Valves, Throttling Control.....The Bantam Catalog No. B-1 and other technical data on Dahl pneumatic and hydraulic valves is available on request.
168 *George W. Dahl Co., Inc.

Process Equipment

Centrifugals.....Booklet No. 2648 illustrates & describes the many units & applications for use with your existing suspended type machines.
194 *The Western States Machine Co.

Clarification.....Bulletin titled "Westfalia Centrifugal Separators" gives detailed explanations of design and operating principles of high-capacity clarifiers.
206B Centrico, Inc.

Converters.....Chemical & Plastic converters are available in a variety of sizes. Complete information on all models is available on request. Send for your copy.
TL201 *Mitts & Merrill

Countercurrent Extractor.....Brochure T-1159 contains information on the Rotating Disc Contactor, a gravity-flow countercurrent extractor. Advantages and design.
206C General American Transportation

Cyclones.....The 1⅛" Cyclone processes up to 2 GPM and is capable of unusually sharp separation in the 15 micron range. Bulletin 1157-CY1 is offered.
TL207 *Heyl & Patterson Inc.

Demineralizers.....are available in mono-column, dual-column & multi-column types...in flow rates from 10 to 10,000 GPH. Fifty standard models to choose from.
R207 *Penfield Mfg. Co., Inc.

* From advertisement, this issue

for Top Performance... it's always

Heyl & Patterson CYCLONES

The H & P 1⅛" Cyclone processes up to 2 GPM and is capable of unusually sharp separation in the –15 micron range. Recoveries approaching 100% have been recorded with fine crystals (1.35 Sp. Gr.), with less than 10% of feed fluid reporting to the thickened product.

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HEYL & PATTERSON Inc.

55 FORT PITT BLVD., PITTSBURGH 22, PA.

VIKING LIQUID ABRASIVE PUMPS NOW LAST LONGER

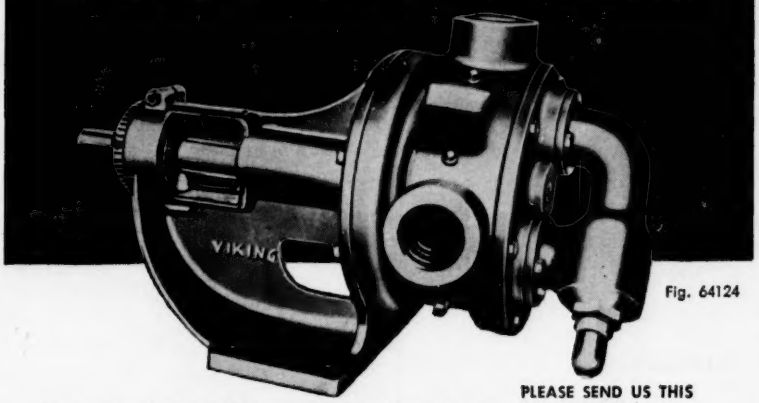

Fig. 64124

Now, you can double or triple pump life with this new heavy-duty Viking. Specially designed with ceramic bearings and mechanical seals to pump paints, inks and other *abrasive liquids. Field tested and proved, pumping liquids from 100 S.S.U. to the heaviest viscous types . . . G.P.M. sizes 3, 6, 12, 16, 25, 40. Let us help you solve your problem.

* Consult factory for recommendations on pumping abrasive liquids other than paints or inks.

PLEASE SEND US THIS INFORMATION:

- Liquid to be pumped
- Viscosity of liquid (S.S.U.)
- Percentage and type of solids present in liquid
- Temperature of liquid
- Specific gravity
- Capacity of pump needed
- Suction lift or head
- Discharge pressure

AND ASK FOR BULLETIN SP-507-C

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Cedar Falls, Iowa, U.S.A. In Canada, It's "ROTO-KING" Pumps

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Need Ultra-Pure Process, Make-Up or Rinse Water?

Check the pioneer maker* of "Packaged" Demineralizers

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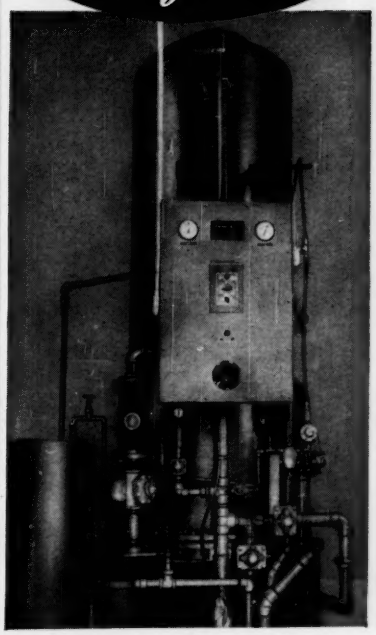

- **Purity in excess of 15-meg ohms** — where you need it, in the quantities you need.
- **Fully Automatic Operation** — set one switch to accomplish entire regeneration cycle.
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Penfield Demineralizers are available in mono-column, dual-column and multi-column types — in flow rates from 10 to 10,000 G.P.H. Fifty standard models to choose from. If complete system engineering is needed, that's a Penfield specialty too.

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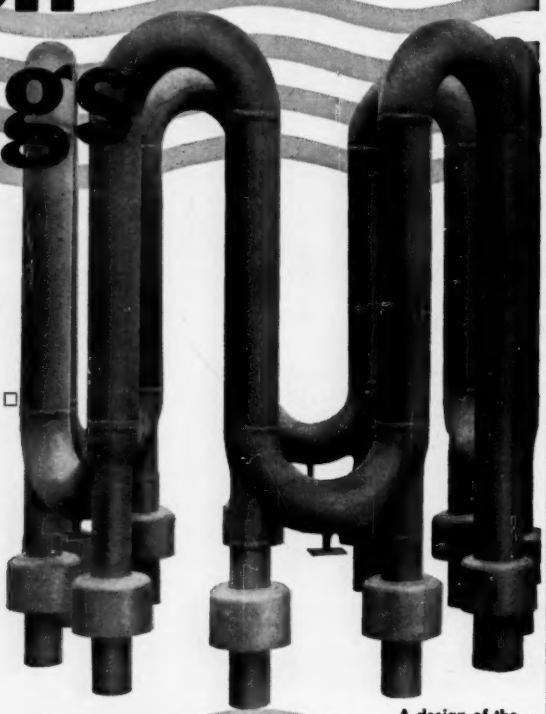
**Penfield pioneered "packaged" demineralizers for American industry — and remains today the only manufacturer exclusively making demineralizing equipment.*

when things are HOT... call on Duraloy



A design of the A. F. Holden Co. Detroit, Mich.

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This "immersion type radiant heater" is typical of the high reliability castings turned out by DURALOY. Centrifugally cast tubes with *UNIFORM* wall thickness...for longest service life. Static cast collars and shell molded bends...typical of DURALOY versatility.

For your high alloy casting requirements check with DURALOY... our long experience, ultra-modern foundry and up-to-the-minute test equipment will be helpful in solving your problems. For more information ask for Bulletin No. 3150 G.

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LITERATURE . . .

Dissolvers.....The new Super Series are high speed, high shear, impeller-type units. Handle viscosities in excess of 50,000 centipoises. Information.
36 *Morehouse Cowles, Inc.

Dust Control.....Complete details on Pangborn's engineering knowledge and experience in dust control is now offered to you. Available on request.
180 *Pangborn Corp.

Dust Filter.....The Dynaclone has new "Resist-O-Wear" filter bags that gives as much as three times longer bag life. A 36-page Catalog 104 is offered.
177 *The W. W. Sly Mfg. Co.

Dynamic Washers.....The UW-4 washers are ideal for high loading conditions. They are self-cleaning and fire and explosion proof. Facts in Bul. W-7456.
20 *The Ducon Co., Inc.

Electric Screens.....Illustrated catalog describes operating principles and application of Hum-mer electric screens. Have no bearings, require no lubrciation. Low power.
208A W. S. Tyler Co.

Equipment.....for elevating & conveying machinery & many industrial applications. Includes chains, sprockets, pillow blocks, pulleys, buckets, etc.
30 *The Jeffrey Mfg. Co.

Filter.....The Eimcobelt filter's new operating principle removes the medium from the drum every filter cycle for cake discharge & cloth washing. Bul. F-2053.
Cover *The Eimco Corporation

Filter.....The vertical leaf pressure filter for large volume clarification, for high filtration efficiency, for quick discharge of solids & easy cleaning. Bul. 146.
167a *T. Shriver & Co., Inc.

Filter Cloth.....Handy comparison chart guides in the selection of filter cloths commonly used in dust and fume collectors. Classifies as to temperature, strength, etc.
208B Whellabrator Corp.

Filters.....Fulflo filters with genuine Honey-comb Filter Tubes for all types of industrial fluids: liquid chemicals, pharmaceuticals, water, oils, compressed air, etc. Catalog.
14 *Commercial Filters Corp.

Flash Drying Systems.....Send for bulletin with further details on equipment that handles the material automatically in a clean, dust-free operation.
86 *Combustion Engineering, Inc.

Gas Diffuser.....The Cavitator is a new method of rapid, low-cost diffusion of a gas into a liquid by mechanical agitation. Illustrated & described in Bul. 150.
208C Yeomans Brothers Co.

Glass-Lined Processing Equipment.... Glass-lined products for the chemical processing industries are all available with Glascote 778. Facts on all products offered.
75-78a *Glascote Products, Inc.

Micronizers.....grind & classify in one operation in a single chamber & provide fines in range from ½ to 44 microns. Eight models are available. Bul. No. 091.
192 *Sturtevant Mill Co.

*From advertisement, this issue

take care of pipeline processes
and they'll take care
of you . . .

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PURIFIERS

Pipeline processes to operate at top efficiency must be kept clean. Hi-eF Purifiers remove contamination from process gas and air lines, entrainment from vapor lines following evaporation, and condensate and oil from compressed gases. The unique two-stage Hi-eF design principle of separation results in low-cost, filterless, maintenance-free operation.
SPECIFICATION MANUAL 803 contains data on 13 types of purifiers, separators, mist extractors, scrubbers. Write. SEND FOR FREE BOOKLET.

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Continuous Dewatering
PRESS
With Variable Speed
Mechanical Feeder

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The physical properties of some products are such that they do not feed from a hopper satisfactorily. To compensate for this, we can supply a mechanical feeder similar to that shown in the accompanying photograph.
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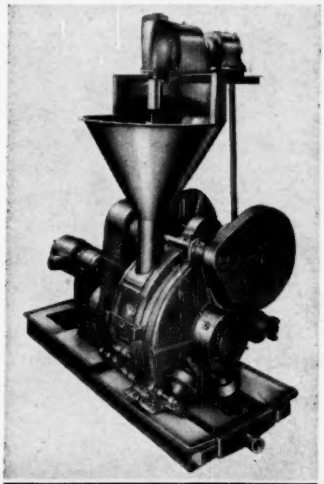
DAVENPORT
Machine and Foundry Co.
Davenport Iowa, U.S.A.



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PRESSING — DRYING
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WATER ANALYZER

Has Guaranteed
Color Standards
That Give
DEPENDABLE
Data

For fast, yet completely accurate tests of color, ammonia, nitrite, nitrate, chlorine, total iron, manganese, silica, copper, fluoride, bromine, aluminum, nickel and low chromate, use a Taylor Water Analyzer. One basic, low-cost unit is adaptable for use with 18 guaranteed color slides. Allows you to make practically any determination required in plant operations. Ideal for obtaining the pH of unbuffered or slightly buffered liquids. Tests are made in only minutes. No fragile glass standards to handle. Complete instructions included with every set.

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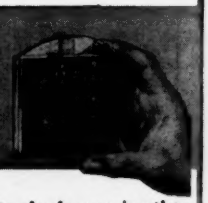
MIDGET
IRON
TESTER



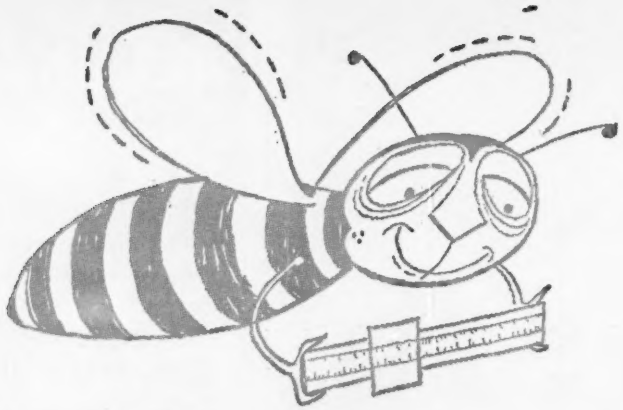
Contains color standards covering the 0-10 ppm range which can be extended by diluting the sample. Sealed-in-plastic color standards virtually eliminate mechanical error.

Also available—
TAYLOR COMPARATORS
for testing pH, phosphate

Be sure to use only Taylor reagents and accessories with Taylor Comparators to assure accurate results. Taylor color standards are guaranteed against fading.

SEE YOUR DEALER for Taylor sets or immediate replacement of supplies. Write direct for FREE HANDBOOK, "Modern pH and Chlorine Control". Gives theory and application of pH control. Illustrates and describes full line.

W. A. TAYLOR AND CO.
414 STEVENSON LANE • BALTIMORE 4, MD



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LITERATURE . . .

Mills, Reversible Hammer.....with new dual "2-Point" adjustment insures more uniform grinding. Features reinforced steel plate frame
29 *William Patent Crusher & Pulverizer

Mixers.....New Catalog "D" gives technical data & specifications of the complete line of Mass & Paste mixers & Ribbon mixers with illustrations of equipment, etc.
210A Paul O. Abbe, Inc.

Process Equipment.....Catalog guide of compressors, pumps, valves, crushers, grinders, kilns, dryers, pelletizers, coolers and heaters available on request.
210B Allis-Chalmers

Process Equipment.....A new 32-page catalog illustrating & describing colloidal mills, homogenizers, pigment mills & related equipment for various industries is offered.
210C Tri-Homo Corp.

Pulverizer.....The Pulvocron is an advanced impact & air attrition pulverizer combined with internal particle size classifier. Available in 20" & 38" grinding chambers.
69 *The Strong-Scott Mfg. Co.

Purifiers.....Specification Manual 803 contains data on 13 types of purifiers, separators, mist extractors, scrubbers. Booklet available on request.
TL209 *The V. D. Anderson Co.

Press.....The continuous dewatering press with variable speed mechanical feeder. Catalog A for reference on Pressing, Drying and Cooling problems.
BL209 *Davenport Machine & Foundry

Process Equipment.....Fact-packed folder gives complete information on each of the many services. In valuable reference material on process equipment.
179 *Artisan Metal Products, Inc.

Tornado Mill.....The new Stokes Size Reduction literature, Bulletin 350 gives complete details plus specific performance comparisons on typical materials.
199 *F. J. Stokes Corp.

Pumps, Fans, Compressors

Compressors.....from single stage to six stages, from 125 to 25,000 psi pressure for gases as follows: Acetylene, Argon, Ethane, Helium, Nitrogen, Oxygen, etc. Catalog 44.
198 *Norwalk Company, Inc.

Compressors, Rotary.....feature simple design, rugged construction & precision manufacture. The only moving parts are rotor, blades & bearings. Illustrated Bul. C-5A.
22 *Fuller Company

Pump.....Complete information on the No. 20 Type SQ open impeller pump is now available. Many advantages of the fully open impellers on these pumps.
12 *The LaBour Co., Inc.

Pump.....New positive displacement handles without turbulence, pulsation, aeration or agitation, corrosive-problem liquids of high or low viscosity. Catalog P 302.
176 *Waukesha Foundry Co.

* From advertisement, this issue

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author

TALITARIAN. — *n.* One who
tar'i-an-ism (ô-thôr'i-târ'i-ăn
au-thor'i-ta'tive (ô-thôr'i-tā'ti
from, authority; entitled to ob
thoritative teachings. 2. Ha
peremptory. — au-thor'i-ta'tiv
au-thor'i-ty (ô-thôr'i-ti), *n.*; *p*
auctoritas] — 1. Legal or rich
a particular field; as, the Port
[illegible] to, in support of opinic
ony; witness. b A prec
[illegible] or its author. d Just
[illegible] influence of
like. — Syn.
au-thor-i-za'tion (ô'thĕr-i-zā'shŭn
au'thor-ize (ô'thĕr-īz), *v. t.*
commission; as, *authc*
precedent sanction; as, customs
[illegible] fund for. — au'th
au'thor-ized (ô'thĕr-īzd), *adj.*
hority. b Sanctioned or appro

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Write For Bulletin 64-4

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SADDLE BROOK, NEW JERSEY

In Canada:
THERMO ELECTRIC (Canada) LTD.,
Brampton, Ont.

New...from MARSH!

Conduit-type Mastermite. Grommet-type also available.

Small Solenoid Valves that fill a BIG Order

Designed to meet the need for positive-acting tight-seating valves for use on wide variety of media, including oxygen, hydrogen, acetylene, etc.

Two Types:
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Wide range of voltages:
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Small, but with more strength in the Marsh manner. Coils never overheat. Entire assembly leak tight. Remarkably quiet operation. Cleanable without breaking connections. Used in any position. Bodies either brass bar stock or 18-8 stainless steel. All moving parts stainless. Underwriters' approved for use on oxygen and hydrogen and as safety valves.

Write for new bulletin

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Dept. 24, Skokie, Illinois
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

There's no waste water from a V-notch

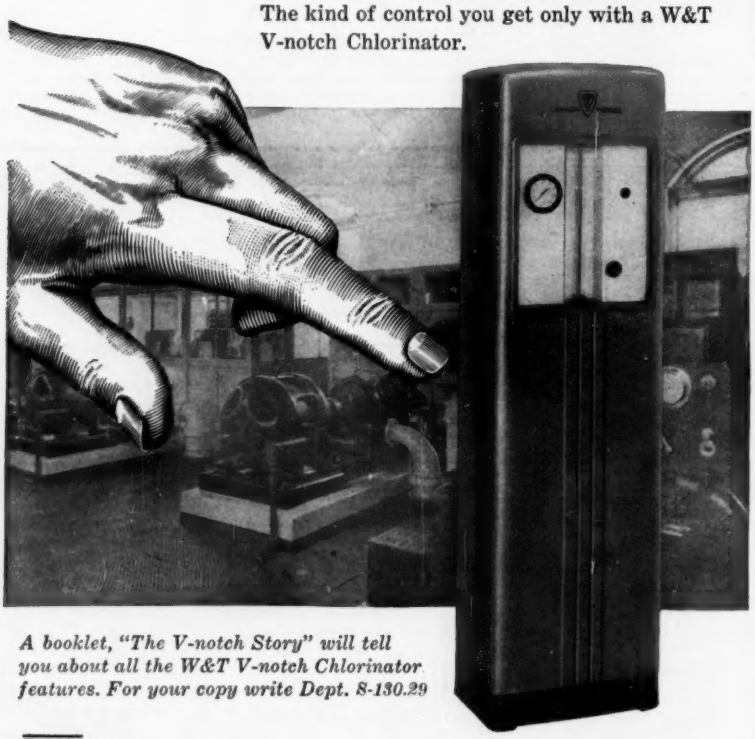
Why?

Because a V-notch Chlorinator needs no auxiliary water supply.

You can plan on clean, dry chlorinator rooms with no messy drain—no chlorine gassing back. And best of all... gone forever is the high cost of wasted auxiliary water.

And, of course, the right plastics make the whole chlorinator chlorine-proof.

Yet these are just added benefits to the main job: Simple, dependable, wide range chlorine control. The kind of control you get only with a W&T V-notch Chlorinator.



A booklet, "The V-notch Story" will tell you about all the W&T V-notch Chlorinator features. For your copy write Dept. S-130.29

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WATER ISN'T CHEAP ENOUGH TO WASTE

W&T controlled chlorination saves water and lowers treatment costs. You get maximum water value and use... even reuse.

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LITERATURE . . .

Pump, Fire.....Brochure lists the outstanding features and the condensed specifications of the model 2F7 Portable Fire Pump. Only 50 lbs. complete with engine.
212A Goodyear Pumps Inc.

Pump, Gear.....Improved design... now 12 gpm. All wetted parts acid-resistant, wear-resistant Ace hard rubber. Complete information in Bul. CE-55.
164b *American Hard Rubber Co.

Pumps.....Literature is available on products for handling corrosive & hazardous processing fluids such as: All-Chem rotary pumps, Gearchem gear pumps, etc.
23 *ECO Engineering Co.

Pumps.....Triplex pumps handle large volume of all types & densities of fluids. Horizontal design provides well area separating product from crank case. Bul. P-55.
221 *Manton-Gaulin

Pumps.....Liquid abrasive pumps are specially designed with ceramic bearings & mechanical seals to pump paints, inks & other abrasive liquids. Bul. SP-507-C.
BL207 *Viking Pump Co.

Pumps, Chemical Feed.....New 200 Series Simplex model can pump up to 812 gph. Duplex model has double this capacity. Maximum pressure of 10,000 psi. Details.
166 *American Meter Co.

Pumps, Leakproof.....Literature describes complete line of seal-less pumps for leakproof pumping. Bulletin 1100 covers design, operation and selection of canned pumps.
212B Fostoria Corp.

Pumps, Mechanical Booster.....are packaged high-speed pumping systems that feature automatic push-button operation. Complete specification on all models.
163 *F. J. Stokes Corp.

Pumps, Metering.....Bulletin describes the line of Pulsafeeder automatic metering chemical pumps for corrosive chemicals. Covers, typical applications. Illustrated.
212C Lapp Insulator Co., Inc.

Services & Miscellaneous

Corrosion Prevention.....Simple, economical way to prevent metal corrosion is the subject of a new catalog. Liquid formula stops attack on wide list of metals.
212D Corrosion Reaction Consultants

Floodlights....Catalog condenses cross-section of information on manufacturer's line of cast aluminum outdoor floodlights. Illustrations and specifications.
212E Stonco Electric Products Co.

Gold Plating Formulations.....New 7-page technical paper covers metallurgical properties & applications for low pH acid-type gold plating formulations.
212F Sel-Rex Corporation

Testing.....8 p. booklet describes company's agricultural services. Outlines steps for soil sampling. Describes soil, fertilizer and plant tissue analysis.
212G U. S. Testing Co.

* From advertisement, this issue

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1—Allis-Chalmers 7' x 50' rotary, ⅝" shell, new gear avail.
2—Hardinge 8'-8" x 70' rotary, ⅝" shell, center heat tube.
8—Rotary dryers: 7'-6" x 60', 6' x 50', 4'-9" x 32', 4' x 30', 3' x 15', etc.
1—Bartlett & Snow 3' x 15' rotary, everdur (95% copper) shell.
2—Stainless rotary dryers: 4' x 12' 3' x 10'.

SPECIAL

1—Vulcan 10' x 11' x 175' long rotary kiln, ¾" shell, (2) tire.
2—7'-6" dia. x 100' long rotary kilns, ½" shell.

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LIQUIDATING

CHEMICAL PLANT—ORANGE, TEXAS

1—Struthers Wells 630 sq. ft. T316 SS evaporator.
2—1,800 cu. ft. Read weight hoppers, T304 SS, 11'10" x 10'5" x 10'2", hopper bottom, fulcrums, scales avail. w/bucket elevators, conveyors, etc.
3—Worthington 160 ton steam-jet vacuum refrigeration units.
3—18,000 gal. alum. cone-bottom tanks, 12' x 31' OAH.
2—Buffalo T316 SS blowers, 2330 cfm, 60 HP, TEFC motors.
2—American T316 SS blowers, 5600 cfm., 50 HP, TEFC motors.

CENT.—FILTERS—CRYSTALLIZERS

2—Sharples #16-P Pressurtite, T304 SS.
2—Sharples C-20 Super D-Hydrators, T316 SS.
1—Alco 110 sq. ft. pressure leaf filter, T316 SS.
4—Struthers-Wells vacuum crystallizers, 1200 gal., T316 cone bottoms.
1—Eimco T304 SS rotary vac. filter, 18" dia. x 24" face.

EXCHANGERS—CONDENSERS—COOLERS

12—800 sq. ft. T316 SS heat exchangers, removable bundle.
75—T316 tubular heat exchangers & condensers, 2000, 1450, 880, 800, 750, 600, 530, 427, 400, 300, 264, 250, 235, 200, 185, 165, 150, 125, 64, 50, 47, 30 sq. ft.
25—Copper & Cupro-Nickel heat exchangers & condensers, up to 1070 sq. ft.

TYPE 316 SS KETTLES

1—3,500 gal. Struthers-Wells vert., 7' dia. x 12" high, jacketed, int. coils, 40/20 HP agit.
1—2,830 gal. horiz. still kettle, 6' x 12' 100 sq. ft. int. coil.
2—2,250 gal. vert., 7' dia. x 6'3" high, jacketed, 3 HP agit.
1—2200 gal., 6'6" x 8' vacuum, jacketed, agit. T316 SS.

TYPE 316 STAINLESS STEEL PRESSURE TANKS

1—17,500 gal. horiz., 9' dia. x 36' long, ¼" shell, ⅜" dished heads, 40# WP
1—2,800 gal. horiz., 6' x 12', 5/16 shell & dished heads, VACUUM, or 80# WP
3—2,750 gal. vert., 7' x 8', dished heads, int. coils, 50# WP
9—2,600 gal. vert., 7' x 8', int. coils, 19# WP, 5 HP Agit.
5—2,250 gal. vert., 7' x 6'3", dished heads, (some w/agit., some w/jacket), 70# WP
1—1,900 gal. vert., 6' x 8', ⅜" shell & dished heads, VACUUM, or 100# WP
4—1,200 gal. vert., 5' x 7', dished top, cone bot., VACUUM, or 100# WP
1—1,000 gal. vert., 5' x 7', 3/16" shell, ¼" dished heads, 60# WP
6—685 gal. vert., 3' x 13', internal coils.
1—575 gal. vert., 4' x 6', dished heads, 90# WP, 355 sq. ft. int. coils.
50—Tanks & pots, 30 to 500 gal., T316 SS.

COLUMNS—STAINLESS STEEL

1—110" dia. Vulcan, 10 trays—bubble caps, T316 SS.
2—96" dia. Vulcan, 30 trays—bubble caps, T316 SS.
1—96" dia. Vulcan, 10 trays—bubble caps, T316 SS.
2—60" dia. Vulcan, 10 trays—bubble caps, T316 SS.
1—48" dia. Vulcan, 25 trays—bubble caps, T304 ELC SS, 100 PSI.
3—24" dia. Vulcan, 12 trays—bubble caps, T316 SS—VACUUM.
6—T316 SS Packed Columns: 42", 36", 30" dia.
5—Steel Packed Columns: 60", 48", 36", 30", 20".

COLUMNS—COPPER

5—Vulcan copper bubble-cap columns, VACUUM! 72" x 40 plate; 48" x 25 plate; 48" x 22 plate; 24" x 20 plate.

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1500 T316 SS flanged valves, globe or gate, ½", 1", 1½", up to 12".
7500—T316 SS pipe, schedule 40, 10, 5, sizes ½", 1", 1½", 2" up to 12".
35—T316 SS pumps, sizes from 6" x 5" to 1" x 1".
1—Otis elec. freight elevator, 5,000# capacity @ 75 FPM.
2—Stainless steel reoilers.
2—Stainless steel bucket elevators, 60' & 40' high.
1—2,100 gal. vert. alum. tank, coils.
10—T316 SS separators, 22" x 8' deep.
1—2,000 gal. copper tank.
3—18,000 gal. steel tanks.

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1—17,850 gal. stainless steel storage tank, 9' x 36', 3/8" material throughout

1—York Shipley 175 HP package steam generator, 150 psi

2—Stokes Model 138J-20 single door vacuum shelf dryers, 20 shelves, complete

2—Sturtevant #7 SS dust type rotary batch blenders, new

AUTOCLAVES KETTLES AND REACTORS

1—Steel and Alloy Tank Co. 100 gal. type 347 SS pressure tank, 250 psi jacket
1—Blaw Knox 400 gal. steel jacketed autoclave, 570# internal pressure, 85# jacket
1—Blaw Knox 45 gal. jacketed autoclave, 1500# pressure
2—Pfaudler 200 gal. glass lined reactors with impeller type agitators and drives
1—Pfaudler 50 gal. glass liner jacketed reactor complete with agitator and drive
1—Edgemoor type 316 SS 750 gal. jacketed reactor
1—Struthers Wells 500 gal. nickel jacketed reactor
1—Patterson-Kelly 6000 gal. steel jacketed reactor, 40# jacket, complete with agitator and drive
1—Patterson 2000 gal. steel jacketed reactor
2—Haveg 300 gal. pressure vessels, complete with agitators and drives
28—30,000 gal. steel vertical storage tanks

DRYERS

1—Link Belt steel roto louver dryer, Model 1003-30
3—Link Belt steel roto louver dryers, Model 207-10, 310-16, 604-20
1—Stokes Model 59DS steel rotary vacuum dryer, 5' x 30'
1—Buflovak SS rotary vacuum dryer, 3' x 15'
1—Stokes double drum dryer, 5' x 12'
1—Louisville rotary steam tube dryer, 8' x 45'
2—Louisville rotary dryers, 8' x 50', SS
1—Louisville SS rotary kiln, 30" x 28' complete
1—Louisville rotary dryer, 38" x 40', Type L
1—Traylor 4' x 40' rotary dryer
1—Rotary dryer 6' x 36'

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
1—Sweetland #3 stainless steel filter
12—Sweetland #12 filter with 72 SS leaves
1—Niagara SS filter, Model 510-28
1—Oliver horizontal filter, 3'
1—Oliver type 316 SS precoat filter, 3' x 4'
1—Oliver SS pressure precoat filter, 5'3" x 8'
10—Shriver plate and frame filter presses, 12" to 42"
1—Shriver aluminum 30" x 30" P & F filter press, 30 chambers
1—Shriver C. I. plate and frame filter press, 36" x 36" closed deliver, 4 eye, 60 chambers
1—Shriver rubber lined filter press, 36" x 36"

CENTRIFUGES

1—Tolhurst SS 20" suspended type centrifuge with perforated basket, complete with plow and motor
1—AT&M 26" suspended type centrifuge with SS perforated basket, complete with plow and motor
1—AT&M 48" SS suspended type centrifuge, complete with plow, motor and imperforated basket
1—Bird type 316 SS centrifuge, 32" x 50"
4—Tolhurst center slung rubber covered centrifuges with perforated baskets and motors
2—Fletcher 40" center slung rubber covered centrifuges with perforated baskets and motors
1—AT&M 40" SS suspended type centrifuge complete with motor, perforated basket and plow

THE GELB GIRL—JANUARY 1960

MIXERS

15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
3—Robinson type 316 SS sigma blade jacketed heavy duty mixer, 400 gal.
1—Baker Perkins Size 16, Type UUEM, 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor
1—12' x 4' pug mixer, type 316 SS
1—Patterson type 347 SS jacketed vacuum sigma kneader master, 500 gal.

MISCELLANEOUS

1—Cleaver Brooks 500 HP package steam generator, 200#
2—Cleaver Brooks package steam generators, 50 and 80 HP, 125#
2—Heat Transfer Products steel bubble cap columns, 36" and 42", with 5 and 10 trays
1—Acme steel bubble cap column, 42" dia. with 10 trays
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Vulcan SS bubble cap column, 4' x 28 plates
2—Patterson Kelley steel heat exchangers, 1000 sq. ft. each
6—Struthers Wells heat exchangers, 885 sq. ft.
1—Patterson Kelley steel heat exchanger, 427 sq. ft.
50—Steel heat exchangers from 15 sq. ft. to 400 sq. ft.
9—Davis SS heat exchangers, 145 sq. ft. (NEW)
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 sq. ft. and 600 sq. ft.
3—Robins shaker screens, SS, 3' x 6'
1—Swenson type 316 SS vacuum crystallizer, 3'6" x 12'
1—Swenson type 316 SS vacuum crystallizer, 2' x 12'
1—Blaw Knox steel distillation column, 36" x 40' with 24 trays (NEW)
3—Williams type 316 SS hammermills, Model AK
1—Swenson pilot plant spray dryer
1—Western Precipitation Corp. stainless steel spray dryer, Type N-2, Size 4-25-E
1—Sprout Waldron Model 501-D pelleter
1—Ross 6" x 14", 3 roll paint mill, complete

1—Downington type 316 SS heat exchanger, 750 sq. ft.

6—17,850 gal. steel all welded storage tanks, 3/8" material throughout

2—Sweco 48" SS separators, Model D-2D-8

5—Stokes Model T and R tablet presses

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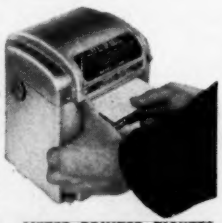

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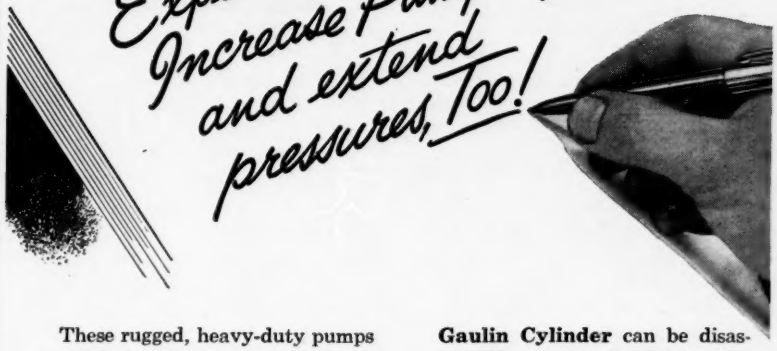

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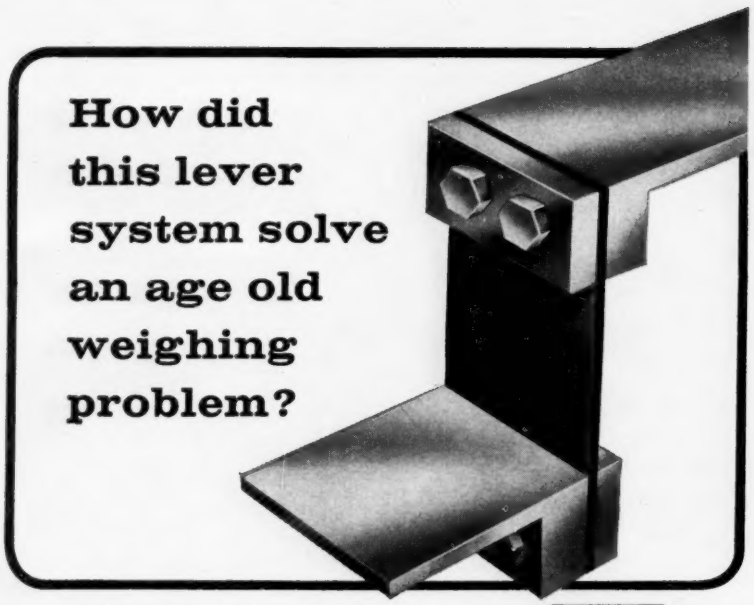

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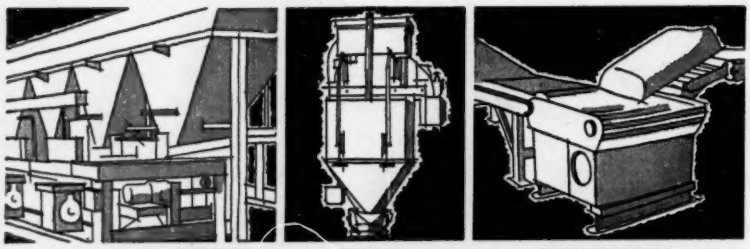

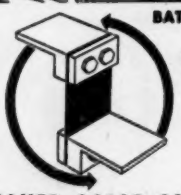

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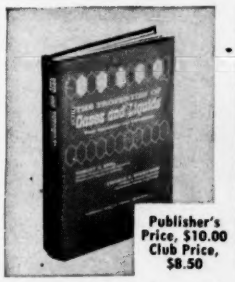

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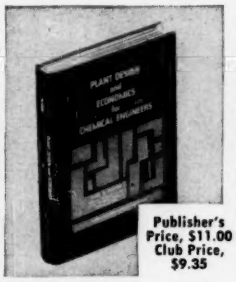

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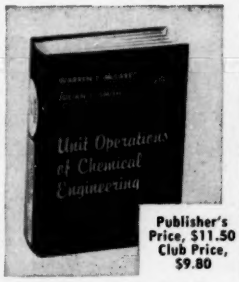

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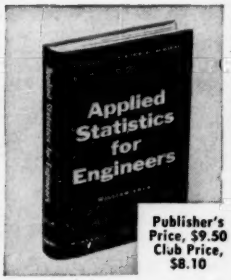

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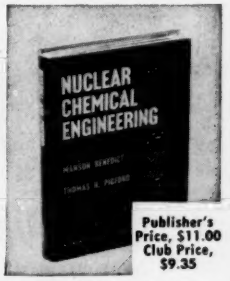

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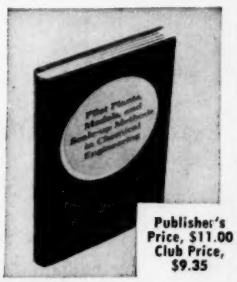

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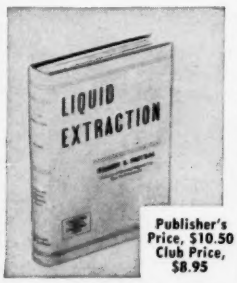

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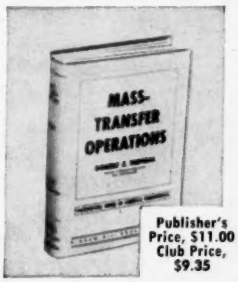

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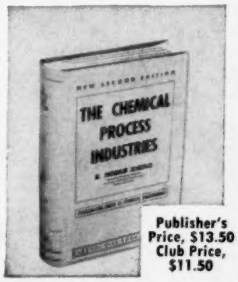

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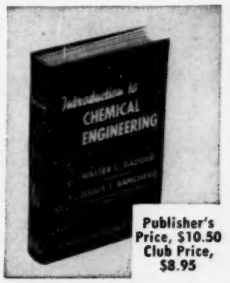

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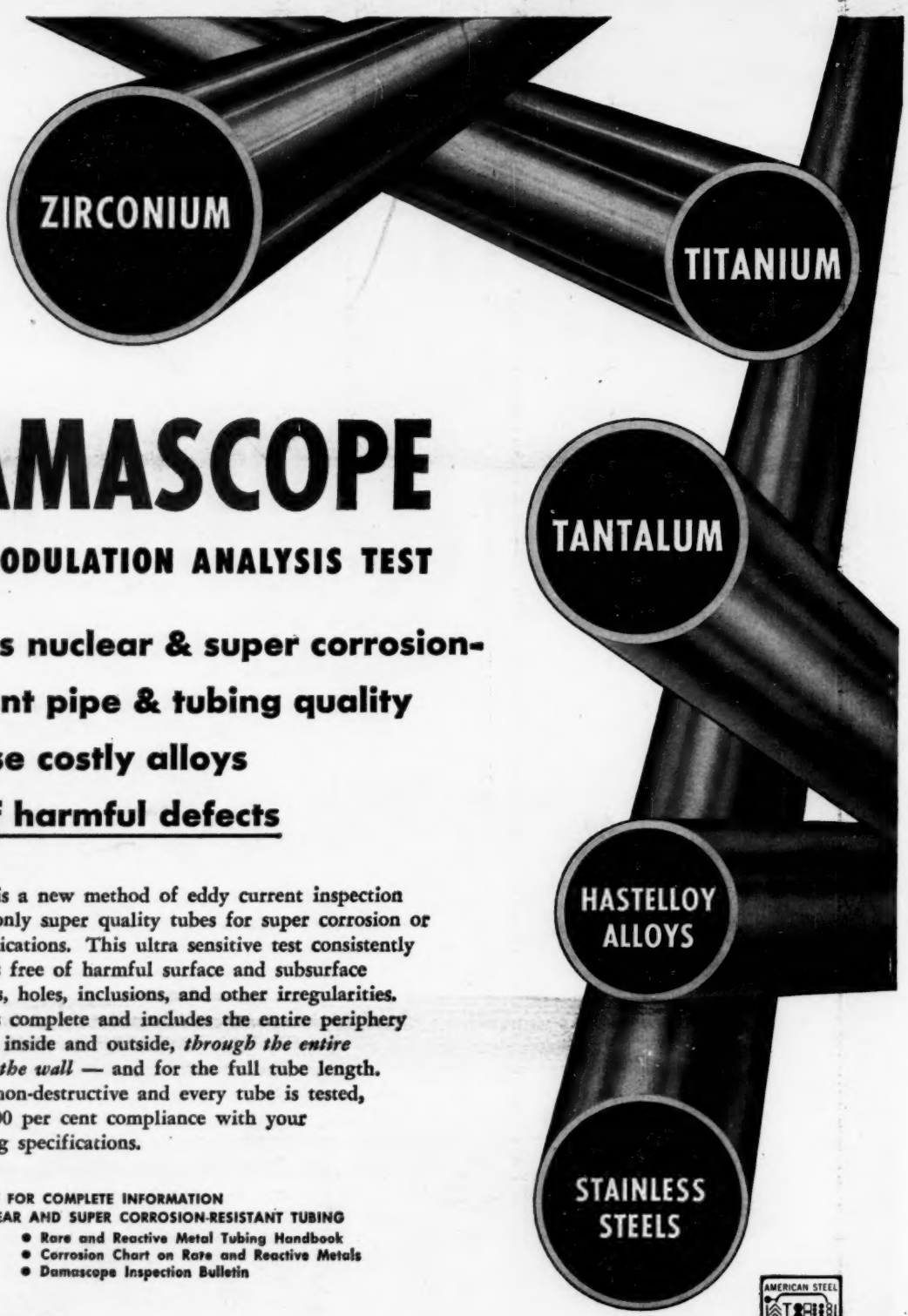

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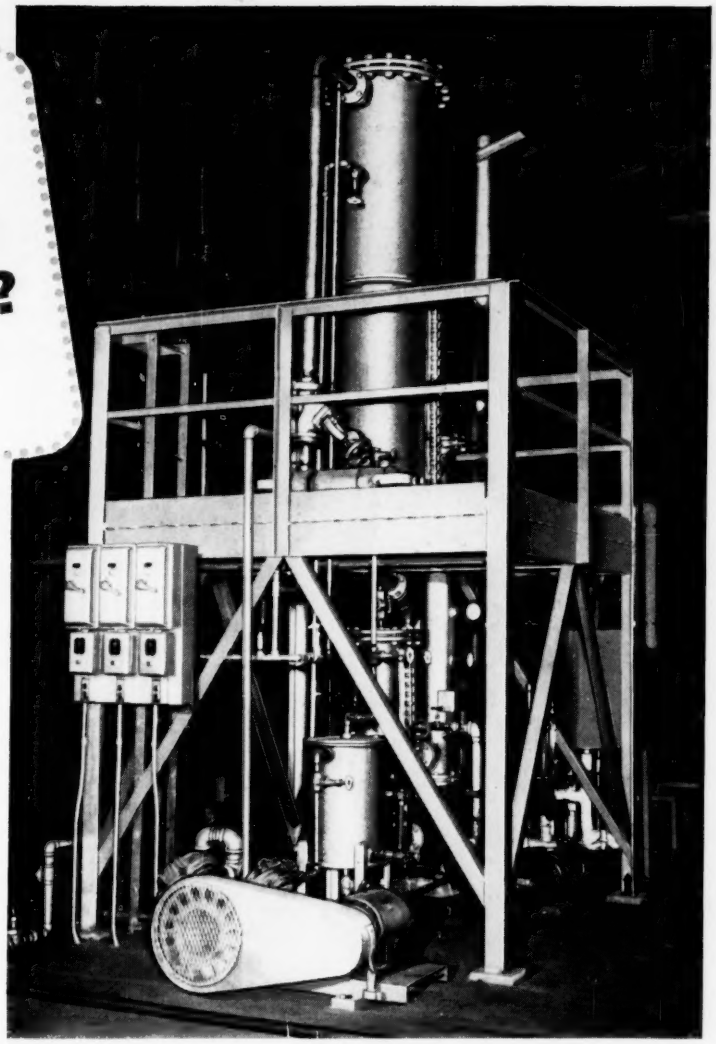

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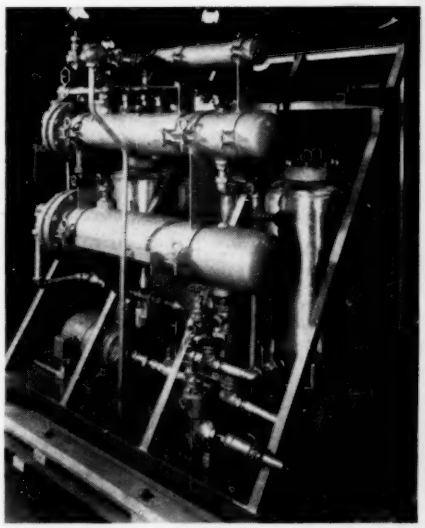

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